STATE OF NEW YORK

DEPARTMENT OF CONSERVATION

WATER POWER AND CONTROL COMMISSION

GROUND WATER IN BRONX, NEW YORK, AND RICHMOND COUNTIES WITH SUMMARY DATA ON KINGS AND QUEENS COUNTIES NEW YORK CITY, NEW YORK

By

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DEPARTMENT OF CONSERVATION

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GROUND WATER IN BRONX, NEW YORK, AND RICHMOND COUNTIES WITH SUMMARY DATA ON KINGS AND QUEENS COUNTIES NEW YORK CITY, NEW YORK

By

NATHANIEL M. PERLMUTTER AND THEODORE ARNOW

ABSTRACT

This reconnaissance report deals primarily with ground water in three of the five Counties in New York City (Bronx, New York, and Richmond Counties). It contains also some references to ground-water conditions in the city as a whole, and summary data for Kings and Queens Counties on Long Island.

New York City is at the mouth of the Hudson River in the southeastern part of New York State. It is built in part on the mainland and in part on three islands, Long Island, Manhattan Island, and Staten Island. Physiographically, the city is partly in the Atlantic Coastal Plain and partly in the Piedmont province.

The consolidated rocks of New York City are pre-Cambrian gneiss, schist, marble, and serpentine, and sandstone, shale, and diabase of Triassic age. The unconsolidated deposits overlying them consist of beds of sand, clay, and gravel of Cretaceous and Quaternary age, ranging in thickness up to about 1,150 feet. Ground-water supplies are closely related to the varied geologic conditions found throughout the city.

Precipitation, which averages 43 inches per year, is the primary source of ground water. The principal aquifers are the glacial deposits which occur in many parts of the city and may yield as much as 1,500 gallons per minute through individual wells of large diameter. The Cretaceous deposits are important as aquifers only in Queens and Richmond Counties. The consolidated rocks supply some ground water in New York and Bronx Counties where in places they represent the only available source of ground-water supply. In 1949, a year of low rainfall and high consumption, about 158 million gallons per day of ground water was consumed in New York City. This was about 13 percent of the total average consumption from all sources of approximately 1.2 billion gallons per day.

Analyses of 69 representative water samples show the wide range in the chemical quality of ground water in New York City. Records of high chloride content in wells in many parts of the city indicate that excessive pumping has lowered ground-water levels apparently sufficiently to permit infiltration of sea water into New York, Richmond, Kings, and Queens Counties. Thus, it is only in a few selected parts of the city, under carefully controlled conditions, that additional large-scale developments for industrial or public supplies can be made without seriously lowering the water levels and enlarging the area affected by salt-water encroachment.

INTRODUCTION

PURPOSE AND SCOPE OF INVESTIGATION

The present report is part of an investigation of the quantity, quality, and occurrence of ground water in the State of New York being made by the United States Geological Survey in cooperation with the New York State Water Power and Control Commission. The objective is to establish the facts on which to base the optimum utilization and conservation of the water resources of the State. Results of the investigation have been released periodically as typewritten manuscripts or published by the Water Power and Control Commission in a series of ground-water bulletins. Most of these bulletins have been prepared cooperatively by personnel of the Survey and of the Commission, although some have been prepared by employees of either of the two agencies working independently. The areas in which investigations have been completed, or in which work is now in progress, are shown in figure 1. Titles of published bulletins are printed on the back cover of the report.

Reconnaissance examinations made by the Geological Survey for the War Production Board during World War II indicated that some ground-water reservoirs in upstate New York were being pumped heavily by industrial and public-supply wells and there was danger of financial loss and public inconvenience because of overpumping in some areas. Consequently, in 1945 the Geological Survey, chiefly in cooperation with the New York Water Power and Control Commission, began a State-wide appraisal of ground-water conditions on a county-by-county basis. It being impracticable to carry on simultaneous investigations in all areas of the State, the first investigations were made in Counties of known heavy ground-water consumption, mainly those containing large cities. The only work done in New York City was in Kings and Queens Counties in connection with the Long Island investigations which had begun on a continuing basis in 1932. No immediate work was planned for Bronx, New York, and Richmond Counties, the part of New York City not on Long Island, because it was felt that the city's surface-water supply available to those Counties obviated the necessity for full utilization of the ground water, and consequently there was no urgent need at that time for information about ground-water conditions. However, in the fall of 1949, owing to a serious decline in storage in the New York City surface reservoirs, many persons considered the possibility of constructing privately owned wells whose supply would not be subject to drought or municipal regulation of consumption. It was felt advisable, therefore, to make a survey of Bronx, New York and Richmond Counties to collect and publish readily available information on the occurrence of ground water in those Counties. The results of this survey are presented herewith.

This report is essentially a reconnaissance report based primarily on well data. Records for about 240 wells and test borings, and chemical analyses of water from 100 wells were collected during 1950-52 in Bronx, New York, and Richmond Counties. The data were obtained from only a few major sources, such as municipal agencies and well drillers, and no attempt was made to canvass these and other wells individually. Accordingly, the information and logs in tables 6 and 7 by no means represent all the wells in the area. Many of the wells are old, and some of them may now have different owners. Information on geologic conditions was derived chiefly from published reports, and from logs of wells and test borings.

The geologic and hydrologic conditions, and the amounts of ground water pumped in Bronx, New York, and Richmond Counties, are different in many respects from those in Kings and Queens Counties. Yet they are all integral parts of New York City. Accordingly, for purpose of comparison, some published and some previously unpublished data on Kings and Queens Counties are included in this report, scattered throughout the text, tables, and illustrations.

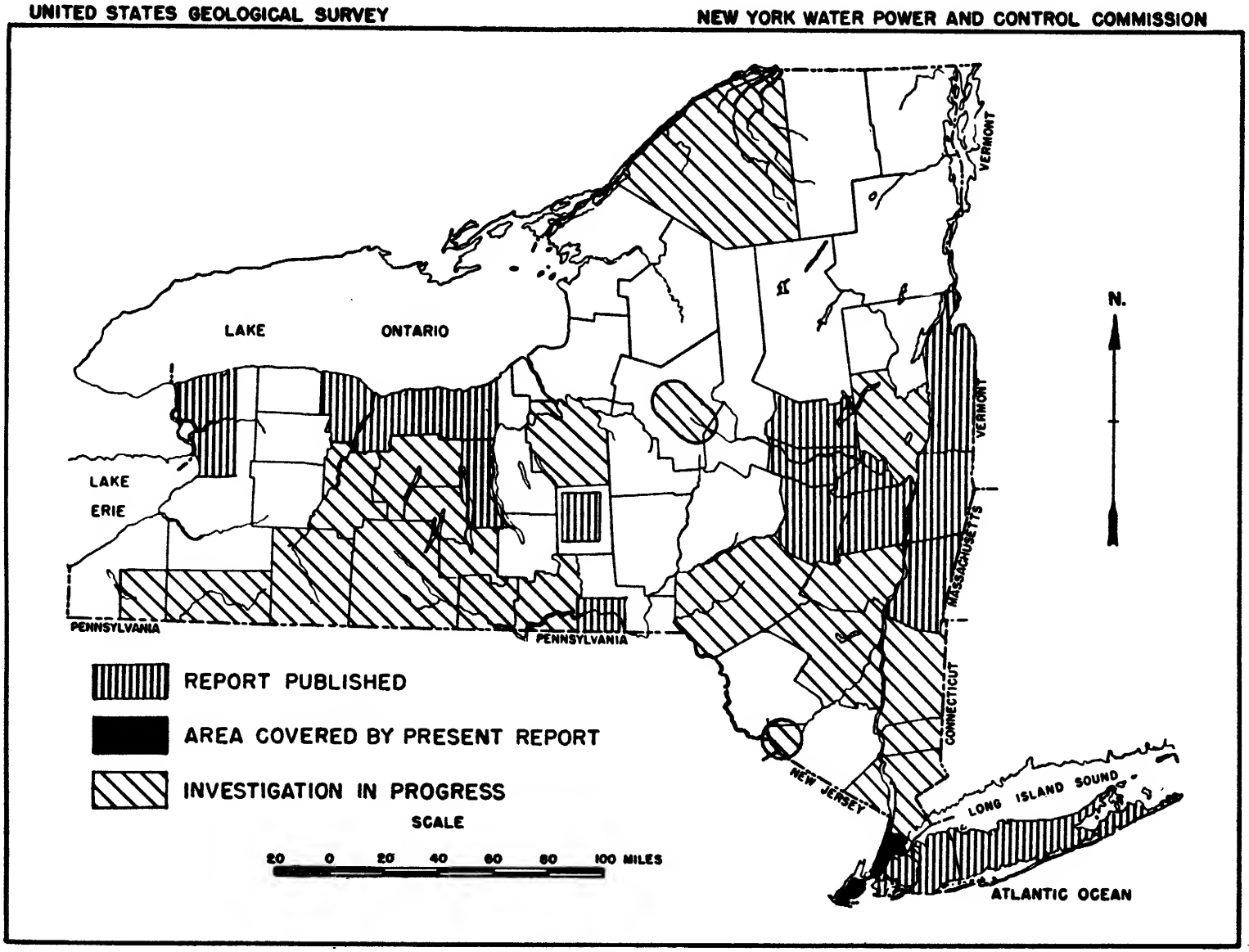

Figure 1.—Map of New York State showing areas of cooperative ground-water studies.

PERSONNEL AND ACKNOWLEDGMENTS

The report was prepared under the general direction of A. N. Sayre, Chief of the Ground Water Branch of the Water Resources Division of the U. S. Geological Survey, and M. L. Brashears, Jr., and J. E. Upson, successive district geologists for New York and New England. L. M. Page, Jr., formerly of the Geological Survey, collected many of the well records here presented. Personnel of the U. S. Geological Survey and the New York State Water Power and Control Commission drafted the maps and cross sections. The following New York City agencies generously contributed information: the Department of Water Supply, Gas and Electricity (Bureau of Water Supply), the Department of Public Works (Subsurface Exploration Section), and the Department of Health (Sanitary Engineering Section). Appreciation is expressed also to local well drillers for making information in their files available for this report.

LOCATION AND DIVISIONS OF THE AREA

New York City is on the east coast of the United States at the mouth of the Hudson River. It comprises two islands, part of a third, and a portion of the mainland. Figure 2 gives the locations of the five component Counties (or Boroughs)[1] and their geographic position with respect to each other. Bronx County is on the mainland, separated from New York County (Manhattan) by the Harlem River. Richmond County includes all of Staten Island, and Kings and Queens Counties are on Long Island. Except for the northern boundary of Bronx County and eastern boundary of Queens County, the city is surrounded by brackish or salty tidewater. According to table 1, Bronx, New York, and Richmond Counties occupy about 38 percent of the total area of New York City and contain about 46 percent of the city's population.

Table 1.—Geographic data for the political subdivisions of New York City

Political subdivision		Geographic location	Population (1950)	Area (square miles)
(State) County	(City) Borough			
Bronx	Bronx	Mainland	1,444,403	41.4
Kings	Brooklyn	Long Island	2,720,238	81.0
New York	Manhattan	Manhattan Island	1,938,551	22.3
Queens	Queens	Long Island	1,546,316	118.6
Richmond	Richmond	Staten Island	191,015	57.0
		Totals	7,840,523	320.3

New York City has 578 miles of waterfront and 5,723 miles of streets. The assessed valuation of taxable real estate for the fiscal year 1948-49, including franchises, was more than 17.5 billion dollars. New York City is one of the leading manufacturing, transportation, and shipping centers, and also one of the cultural centers, of the world.

[1] State and municipal designations of the subdivisions of New York City are used interchangeably in this report. However, in most places the State names are used. (See table 1.)

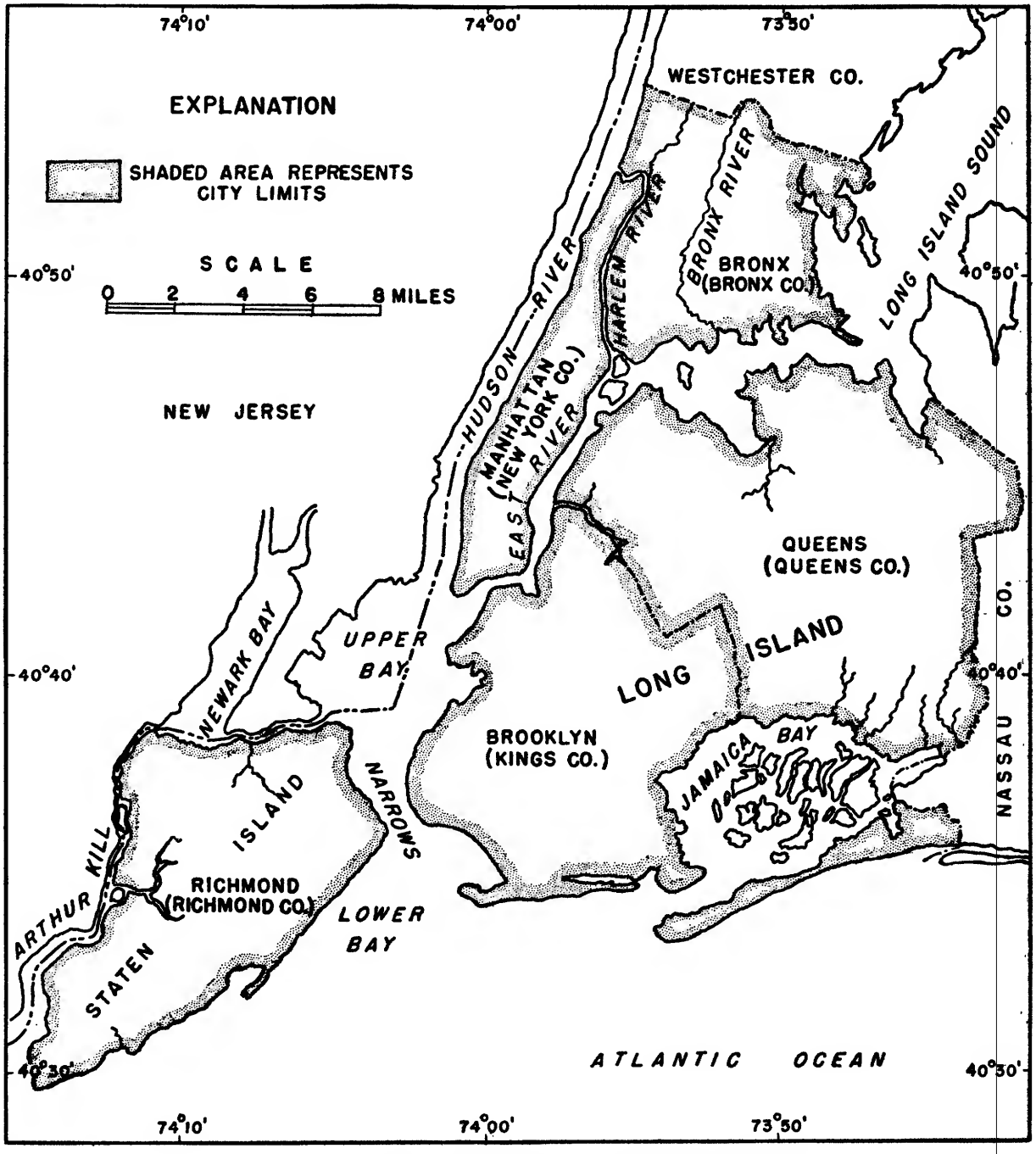

Figure 2.—Map of New York City showing political subdivisions.

TOPOGRAPHY AND DRAINAGE

Ignoring the subdivisions made by the rivers and bays, New York City consists essentially of three physiographically different areas. (See plate 2.) From north to south these are: (1) the area of New York and Bronx Counties, essentially an extension of the upland area that occupies a large part of New England; (2) the northern half of Queens and Kings Counties and nearly all of Richmond County, consisting of the terminal moraine and the hilly till-covered

area north of the terminal moraine; and (3) the southern half of Queens and Kings Counties and a small area in the southeastern part of Richmond County comprising the glacial outwash plain.

The northern area, including all of New York and Bronx Counties, is in the glaciated and eroded southern portion of a more extensive upland. The topography in this area is largely a product of preglacial stream erosion, modified somewhat by glacial erosion and deposition. The upland rises gently from sea level and reaches altitudes of 276 feet in northern Manhattan and 284 feet in western Bronx. It is mainly characterized by parallel, linear ridges and valleys having a northeasterly trend. Bronx County, the only part of the city having an extensive natural drainage system, is drained by the Bronx River, Westchester Creek, the Hutchinson River, and Tibbit Brook, all of which flow southward in narrow, approximately parallel channels. Manhattan was formerly drained by about a dozen shallow creeks which emptied into the Hudson, Harlem, and East Rivers. Most of these creeks now have been filled in and are covered by buildings and streets, but the location of the old channels may have some influence on the occurrence and movement of ground water in the County.

The second or central topographic division of New York Cty includes the terminal moraine and the dissected, rolling area north of the moraine on Staten and Long Islands. In the northern half of Staten Island the topography is irregular with several places reaching altitudes of 300 feet or more above sea level. Todt Hill, a high area composed of serpentine bedrock and partly covered by the terminal moraine, is in this division. It is 409 feet above sea level, one of the highest points on the Atlantic Coast south of Maine. The northwestern shore of Staten Island is formed by low-lying land which in places is tidal marsh. On Long Island, north of the moraine, the land surface is rolling and slopes toward the East River and Long Island Sound. The shoreline is indented by the valleys of several small north-flowing creeks. The highest altitude in this area is actually on the terminal moraine in northeastern Queens where the land surface is as much as 280 feet above sea level.

The southern of the three areas is the glacial outwash plain which lies south and southeast of the terminal moraine. On Staten Island it is about 1 mile wide and on Long Island it is 2 to 9 miles wide. This plain, on both islands, slopes gently toward the Atlantic Ocean and merges into tidal marshes, shallow bays, and barrier beaches at the shore. Altitudes on the outwash plain range from sea level to as much as 40 feet above in Richmond County (Staten Island) and as much as 100 feet above in Queens County. No streams of appreciable size have developed on the outwash plain in Richmond, Kings, or Queens Counties because of the permeable nature of the deposits beneath the plain. The few existing streams are small and occupy shallow, narrow valleys which intersect the water table.

CLIMATE

The U. S. Weather Bureau has been collecting meteorological records in New York City since 1870. There are also additional data, mainly precipitation, collected by other agencies since 1826. The following discussion of the climate of New York City is abstracted from the Weather Bureau's Annual Meteorological Summary and is based chiefly on meteorological observations at the Battery Park station in southern Manhattan.

Despite the nearness of New York City to the Atlantic Ocean and numerous bays and rivers, its climate resembles the continental type more closely than the maritime type. This is because weather conditions affecting the city usually approach from the west, not from the ocean on the east. However, the oceanic influence is not entirely absent. During the summer

months local sea breezes often moderate the afternoon heat, and during the winter coastal storms accompanied by easterly winds may bring considerable amounts of rain or snow.

The mean annual temperature at New York City is 52.6° F. Subfreezing temperatures occur on the average of 92 days of the year; subzero weather may be expected only on two days in every three winters. During an average summer, the mercury reaches the nineties on 7 days. A temperature of 100° F. or higher has been registered about seven times since 1871. During the hot summer afternoons, relative humidity seldom exceeds 60 percent, but some uncomfortable days may be expected each year with a combination of temperature in the eighties and humidity of more than 70 percent.

Precipitation is moderate and is distributed evenly throughout the year. The normal annual precipitation is 42.92 inches, about 25 inches of rain usually falling during the growing season (April through October). A prolonged dry period may be expected every two or three years, usually in September or October. Most of the rain that falls from June to September is derived from thunderstorms. Hence precipitation during the warmer half of the year is usually brief and relatively intense. From October to April, however, precipitation is generally associated with widespread storm areas, so that day-long rain or snow is common. The average yearly snowfall totals about 31 inches, and on the average snow (trace or more) falls on about 35 days from November through April.

GEOLOGY

For a detailed discussion of the geology and geologic history of New York City the reader is referred to U. S. Geological Survey Folio 83 (Merrill and others, 1902) and New York State Water Power and Control Commission Bulletin GW-18 (Suter, deLaguna, and Perlmutter, 1949). The latter report includes data for the Long Island portion of the city only. Both reports contain maps of the surficial and subsurface geology of the city as well as cross sections showing the relationships of the geologic formations.

A generalized stratigraphic column for New York City, summarizing the geologic formations and their hydrologic properties, is shown in table 2. With respect to water-bearing properties, the geologic formations may be divided into two groups, consolidated rocks which contain little water, and unconsolidated deposits which contain large quantities of ground water and generally yield water readily to properly constructed wells. The descriptions of the consolidated rocks are based chiefly on data in Folio 83; the descriptions of the unconsolidated deposits are based in part on data in Bulletin GW-18. Most of the detailed information on the geology of the unconsolidated deposits in New York City is from Kings and Queens Counties where thousands of well records and other data have led to a relatively complete understanding of the geology and hydrology of these deposits. (See references.) Not enough geologic information is available on the unconsolidated deposits in Bronx, New York, and Richmond Counties to correlate them with all the geologic subdivisions recognized in Kings and Queens Counties, but tentative correlations of the major subdivisions have been made.

CONSOLIDATED ROCKS

The consolidated rocks in New York City are of igneous, sedimentary, and metamorphic origin and are pre-Cambrian to Triassic in age. The igneous rocks consist of granite, pegmatite, grandiorite, diabase, and basic dikes. The sedimentary rocks are composed of shale and sandstone of Triassic age which occur only in Staten Island, and the metamorphic rocks consist chiefly of gneiss, schist, and marble. Plate 1, a generalized geologic map of New York City, shows the distribution of the consolidated formations underlying the Pleistocene (glacial) depos-

Table 2.—Geologic formations in New York City and their water-bearing properties

System	Series	Geologic unit	Character of material	Water-bearing properties
Quaternary	Recent	Recent deposits	Thin deposits of alluvial clay, silt, sand, and gravel in the fresh-water channels, but thicker deposits in the tidal channels. Thin deposits of eolian sand, beach sand, and peat. Maximum thickness is at least 100 feet, but the average is much less. Identified in all Counties.	Relatively unimportant owing to thinness of the deposits and their susceptibility to salt-water infiltration.
	Pleistocene	Upper Pleistocene deposits	Till—heterogeneous mixture of unstratified material ranging in grain size from clay to boulders. Varies from place to place and at some places grades into sorted material. Deposited directly by the glaciers. Maximum thickness in terminal-moraine deposits is about 150 feet.	Unimportant as an aquifer in New York City. Yields small supplies of water sufficient for domestic use to wells of large diameter.
			Outwash—sorted and stratified sediments ranging in grain size from clay to coarse gravel. Commonly cross-bedded. Deposited by glacial melt waters. Maximum thickness is about 200 feet. Identified in all Counties.	Most important aquifer in the city. A reliable source of large supplies of water. Water-table conditions prevail. The maximum yield per well reported from the two Long Island Counties is greater than 1,500 gpm. The maximum yield reported in the other three Counties is 500 gpm. The range in yields is affected largely by the location and construction of the wells. Readily subject to contamination by salt water in areas of overpumping near tidal waters. High hardness is an unfavorable characteristic of the water in some areas such as Kings County.
		Gardiners clay	A dark-gray or greenish gray silt and solid clay containing marine microfossils and plant material. May consist of fine sand, sandy clay and scattered discontinuous lenses of coarse sand. The sand consists of quartz, biotite, chlorite, muscovite, amphibole, and pyroxene. Maximum thickness is about 150 feet. Identified in Kings and Queens Counties only. May occur in Richmond County.	Poor aquifer owing to relative impermeability. Acts as a confining layer to create artesian conditions in the underlying Jameco gravel. No wells tap this formation.
		Jameco gravel	Dark-brown to dark-gray or multicolored beds of coarse sand and gravel containing some cobbles, boulders, and scattered layers of silt and clay. Composed chiefly of fragments of quartz, granite, diabase, gneiss, schist, sandstone, shale, and pegmatite. Maximum thickness is about 150 feet. Identified in Kings and Queens only.	Excellent aquifer where present in Kings and Queens Counties. Both water-table and artesian conditions exist. The maximum yield reported is greater than 2,000 gpm. Readily subject to contamination by salt water and now generally yields water of high chloride content.
Cretaceous	Upper Cretaceous	Magothy (?) formation	Fine clayey sand, fine sand, silt, layers of clay, and several zones of coarse sand and gravel. Colors are light and dark gray, brown, buff, yellow, and occasionally red and pink. Consists almost entirely of angular clear quartz but contains lignite, pyrite, chert, kaolin, muscovite, and dark heavy minerals. Maximum thickness is about 400 feet. Occurs in Kings and Queens only.	Zones of coarse sediments constitute excellent aquifers in Queens. Artesian conditions exist. The maximum yield reported is greater than 1,100 gpm. Less easily subject to infiltration of salt water than overlying deposits. Water generally of good quality.
		Raritan formation: Clay member	Laminated silt and clay and subordinate sandy layers. Clay is predominantly light and dark gray, but may be red, white, yellow, or mottled. Layers of lignite and pyrite interbedded with carbonaceous clay are common. Maximum thickness is about 300 feet. Occurs in Kings, Queens, and Richmond Counties.	Poor aquifer owing to relative impermeability. Acts as a confining layer for the underlying Lloyd sand member.
		Raritan formation: Lloyd sand member	Medium to coarse sand and fine to medium gravel which contain beds of fine sandy clay, clayey sand, and relatively thin layers of clay. The amount of clay differs considerably from place to place; the clay may fill the pore spaces between the coarser particles. Sand and gravel consist almost entirely of quartz. Maximum thickness is about 300 feet. Identified in Kings and Queens, and probably occurs in Richmond County also.	Zones of coarse sediments that do not contain much clay constitute excellent aquifers in Kings and Queens. Artesian conditions prevail. The maximum yield reported is about 2,000 gpm. Less easily subject to infiltration of salt water than any of the overlying aquifers. Water may require treatment for removal of iron.

Table 2.—Geologic formations in New York City and their water-bearing properties (Continued)

Triassic	Upper Triassic	Palisade diabase	Predominantly a medium- to coarse-grained dark-gray rock of intrusive origin consisting chiefly of the minerals plagioclase, augite, and hypersthene. Occurs as intrusive bodies in Newark group in Richmond.	Unimportant as an aquifer. Minor faults and joints are numerous. Few well records. Records of wells in the diabase elsewhere in the State show an average yield of less than 10 gpm.
		Newark group, undivided	Alternating beds of comparatively soft, brownish-red sandstone and shale. The sandstones are cross-bedded in places and bear evidence of shallow fresh-water deposition. Identified in northwestern Richmond only.	Unimportant as an aquifer. Few well records. Records of wells in nearby areas in New Jersey and Rockland County, N. Y. show an average yield of about 75 gpm and a range in yield from less than 1 to 700 gpm.
Pre-Cambrian (?)		Staten Island serpentine of Merrill (1898)	Serpentine that ranges widely in color and texture. Generally compact and light green but may be dull red owing to the presence of iron. Probably derived from basic intrusives. Underlies a large area in central and northeastern Richmond.	Unimportant as an aquifer because of low permeability. Records of 5 wells shown an average yield of 5 gpm and an average depth of 300 feet.
Pre-Cambrian		Igneous intrusives	Pegmatite, injection granite, granodiorite, gneissoid granite, and basic dikes and injections.	Unimportant as aquifers because of low permeability and small area of outcrop. No well records.
		Manhattan schist	Coarsely crystalline mica schist which has been severely crumpled and folded and shows a marked foliation. A recrystallized sediment which has lost its sedimentary character through severe metamorphism. Maximum thickness is about 3,000 feet. Crops out in New York and Bronx counties.	Unimportant as an aquifer because of relative impermeability. Records of 15 wells show an average yield of 40 gpm and an average depth of 320 feet.
		Inwood limestone	Coarsely crystalline and distinctly bedded marble. Subject to solutional action and consequently forms topographic lows which may be covered by deposits of stratified drift. Maximum thickness is about 700 feet. Identified in New York and Bronx Counties but may underlie a small area in northwestern Queens County.	Relatively unimportant as an aquifer because of small area of outcrop and fairly low permeability. Records of 18 wells, in Bronx County, show an average yield of 75 gpm and a range in yield from 1 to 300 gpm. The average well depth is 340 feet. Ground water in the Inwood is the hardest in the city, averaging about 375 ppm.
		Fordham gneiss	A gray thin-bedded gneiss. Some of the bands are highly quartzose, some are composed largely of biotite, and some consist of pegmatite or granite which seems to have been injected parallel to regular banding of the gneiss. Considered as partly sedimentary and partly igneous in origin. Maximum thickness is unknown. Occurs mainly in Bronx County.	Unimportant as an aquifer because of relative impermeability. Records of only 2 wells obtained. Yields are 5 and 35 gpm and depths range from 98 to 250 feet.

its. The consolidated rocks are exposed or are close to the land surface in much of northern New York and Bronx Counties. In Richmond County, the serpentine bedrock in the central part of the County is exposed in a few places but is generally covered by unstratified glacial drift or other deposits. In Kings and Queens Counties the surface of the bedrock slopes about 80 feet per mile to the southeast and is buried under Cretaceous and Pleistocene deposits aggregating as much as 1,150 feet in thickness. Bedrock is exposed in Long Island only in a small area near Astoria in northwestern Queens County. Only a few wells now take water from the bedrock in western Long Island.

The igneous and metamorphic rocks in New York City are crystalline and contain practically no pore spaces. They do, however, contain joints, openings along cleavage planes, and other fractures through which small amounts of ground water may move. Larger quantities of water occur in the Inwood limestone, a metamorphic rock, in which the openings have been enlarged by solution. The sedimentary rocks yield water chiefly from joints, and openings along bedding and fault planes. Some water may be held in the pore spaces between the grains of which the rocks are composed. The volume of water held in this manner is generally small but varies depending upon the kind and amount of cementation of the rock, and the size of the pores.

UNCONSOLIDATED DEPOSITS

The unconsolidated deposits which overlie the consolidated bedrock of New York City consist of beds of gravel, sand, silt, and clay. The deposits range in geologic age from Cretaceous to Recent and are divided into two groups: deposits of Cretaceous age, and deposits of Quaternary (Pleistocene and Recent) age. The distribution of the deposits is shown in plates 1 and 2. As the Pleistocene and Recent deposits are difficult to differentiate, both are usually mapped as a single unit. The unconsolidated deposits are thickest in Kings and Queens Counties (up to 1,150 feet) and have a considerable range in thickness in the other Counties, reaching a maximum thickness of about 400 feet in Richmond County.

Deposits of Cretaceous Age

The deposits of Cretaceous age are important or potentially important as sources of ground water only in Richmond and the Long Island Counties. They are entirely absent in Bronx and New York Counties. The deposits originated mainly as stream deposits of the flood-plain and deltaic varieties and consequently show marked variations in texture and sorting both vertically and horizontally. The sediments range from solid clays to relatively clay-free beds of fine to coarse sand and gravel. Between these extremes are mixed textural types such as clayey sand, sandy clay, and clayey gravel. These materials, in general, occur in discontinuous lenses which may or may not be traceable from one well to another. Wells screened in Cretaceous deposits require more development than wells screened in glacial deposits because of the high percentage of clay and silt. Nevertheless, modern development techniques have produced many wells yielding large quantities of water from Cretaceous beds.

Geologists have divided the Cretaceous beds of Long Island into three major units (see table 2), from bottom to top the Lloyd sand member of the Raritan formation, the clay member of the Raritan formation, and the Magothy (?) formation. These deposits range in combined thickness from a featheredge at their northwestern limit to about 1,000 feet in southeastern Queens County. Data collected indicate that the Raritan formation underlies the southeastern part of Richmond County also, but not enough well logs and samples were obtained to subdivide

the formation (except to say that the upper or clay member is almost certainly present and also sandy zones perhaps equivalent to the Lloyd sand member.) No younger Cretaceous formations were recognized.

Deposits of Pleistocene and Recent Age

Much of the surface of Richmond, New York, and Kings and Queens Counties is immediately underlain by unconsolidated deposits of Pleistocene and Recent age. In Bronx County the deposits are thinner and more outcrops of rock are evident than in other parts of the city, but these are too small to be shown individually on plate 2. The deposits consist of four units: (1) unstratified drift forming the Harbor Hill terminal moraine; (2) unstratified drift forming ground moraine; (3) stratified sediments, largely outwash sand and gravel deposited by streams from melting glaciers during several stages of ice advance, but locally including beds of clay which may be the equivalent of the Gardiners clay (the lowermost portion of these deposits may represent the Jameco gravel described in table 2 and beyond); and (4) alluvium of Recent age. On the map, plate 2, only the Harbor Hill terminal moraine, the ground moraine, and the uppermost (youngest) outwash deposits are shown as both the Gardiners clay and the Jameco gravel do not crop out.

The terminal moraine, the Harbor Hill moraine, forms a conspicuous hummocky ridge which, within the city, extends from northeastern Queens to the Fort Hamilton area in southwestern Brooklyn, where it is cut by the Narrows, and reappears on Staten Island to the southwest. The morainal ridge is composed of relatively impermeable unstratified till which ranges in thickness from about 25 to 150 feet. Huge boulders, generally characteristic of these deposits, make drilling through the moraine a slow and difficult process.

The ground moraine consists of brown, unstratified clay, boulders, and sand. It occurs as the uppermost deposit in the area north of the terminal moraine where it forms a relatively thin veneer (generally about 2 to 35 feet thick but as much as 85 feet thick in a few places) over the underlying bedrock or deposits of outwash. The ground moraine is of low permeability and in most places is a poor source of water. However, in some parts of the city, as in northern Richmond, Kings, and Queens Counties, (see pl. 2), it locally overlies outwash sand and gravel which is excellent water-bearing material.

The outwash sand and gravel deposits contain abundant ground-water supplies in southeastern Richmond and southern New York Counties and most of Kings and Queens Counties. These well-sorted sediments were deposited in flood plains, deltas, and fans in front of the glaciers by melt-water streams. They are porous and highly permeable. Outwash deposits in Kings and Queens Counties, comprise two distinct units separated by the interglacial Gardiners clay. The older, lower, unit is called the Jameco gravel; the upper unit is part of the post-Gardiners deposits referred to on Long Island, as the upper Pleistocene deposits (Suter, and others, 1949, p. 24). The Jameco gravel and the Gardiners clay have not been positively identified in Bronx, New York, and Richmond Counties, and most of the glacial deposits in those Counties probably are the equivalent of the upper Pleistocene deposits of Long Island. However, some of the deeper valley-fill deposits in Richmond and Manhattan may be the equivalent of the Jameco gravel.

As determined from studies on Long Island, the Gardiners clay, separating the Jameco gravel and the upper Pleistocene deposits, was laid down probably in tidal estuaries and embayments during an interglacial stage when sea level was about 50 feet lower than the present level and the ice had melted completely away from this area. Upon readvance of the ice the younger, upper Pleistocene outwash was deposited on the marine clay. There is some evidence

that locally, as in Kings County, the clay was not deposited or was cut through by streams before the deposition of the younger outwash which therefore in places may rest directly on the Jameco gravel. Thus, the geologic and hydrologic conditions in the Pleistocene deposits in Kings and Queens Counties are complex. Similar conditions may occur in the other Counties where corresponding erosional and depositional events may have taken place.

The alluvium of Recent age is of little importance as a source of ground water in New York City. Few wells are constructed in these deposits as they are generally contaminated by sea water. The deposits, ranging in thickness from several feet to as much as 100 feet, consist of white to gray sand and gravel, usually containing broken shell fragments, and layers of dark gray organic clay and silt. The clay and silt help to seal the fresh-water aquifers against salt-water intrusion. Some thin deposits of Recent age may occur in the valleys of the streams draining Bronx County, but most of the deposits occur beneath the beaches, offshore bars, tidal channels, and embayments bordering the city.

GROUND WATER

OCCURRENCE AND AVAILABILITY

The primary source of ground water in New York City is precipitation (rain and snow) on the land surface, which averages about 43 inches per year. Part of this is disposed of by direct surface runoff into streams and lakes; evaporation from the land surface, wetted vegetation, or structures of man; transpiration by plants; and drainage into sewers in areas where the streets are paved and buildings have been erected. The remainder of the precipitation percolates downward and becomes part of the ground water. It is estimated that probably less than 50 percent of the total precipitation enters the ground-water reservoirs in Kings, Queens, and Richmond Counties. In Manhattan and Bronx which are covered almost entirely by buildings and paved streets, and are underlain also by relatively impermeable rock, recharge from precipitation is probably much less than 50 percent. Other, secondary, sources of ground-water recharge in the city are leakage from sewer and water lines, infiltration of surface water, and movement of water into the city from adjacent areas. These sources are discussed more fully for each County in the following pages.

Most of the ground water in New York City is held in the pore spaces of the unconsolidated deposits of Cretaceous and Pleistocene age. In some of these deposits, especially the Cretaceous deposits, water is held under artesian pressure in permeable beds confined beneath clay layers. Water occurs also in the consolidated rocks in joints or other fractures which make relatively large openings. In much of northern Richmond, Bronx, and Manhattan, these openings in the bedrock are the only source of ground water.

Bronx County

Characteristics of the Water-Bearing Formations

Bronx County is underlain by consolidated pre-Cambrian rocks. The three most extensive formations are, from oldest to youngest, the Fordham gneiss, the Inwood limestone, and the Manhattan schist. The pre-Cambrian Lowerre quartzite and Yonkers granite crop out in several small areas, but, owing to their limited areal distribution and relatively impermeable nature, those formations are of little importance to this investigation and are not shown on plate 1; no records of wells penetrating them were obtained.

The strata of the three principal formations are tightly folded, and both the folding and subsequent erosion have produced a belted outcrop pattern and also a series of northeast-

trending ridges and valleys. The eastern two-thirds of Bronx County is underlain by the Manhattan schist; the western third by the Fordham gneiss and narrow bands of infolded Inwood limestone (pl. 1). The limestone typically underlies the low areas, forming long, narrow valleys. Figure 3 gives a generalized geologic section across the southern part of Bronx County illustrating the structural relationships of the formations.

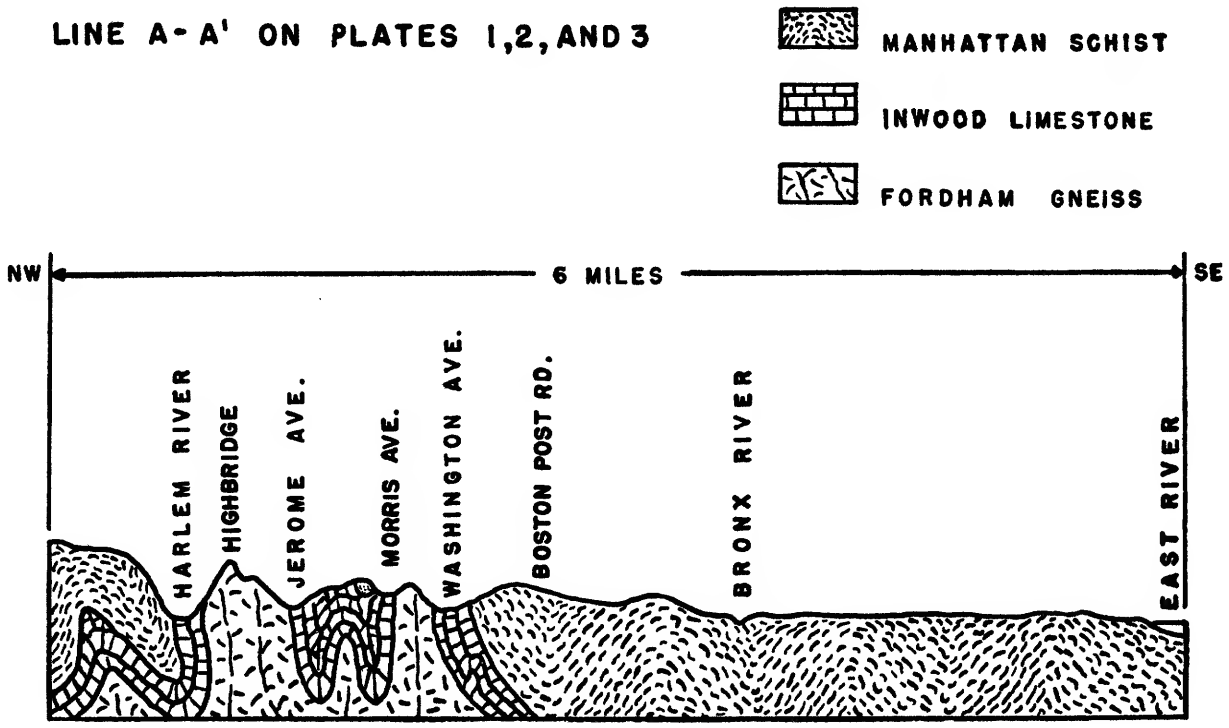

Figure 3.—Northwest-southeast generalized geologic section in Bronx County.

During the Pleistocene epoch a relatively thin covering of glacial deposits, consisting chiefly of till, was laid down upon the pre-Cambrian rocks, and some stratified drift was deposited in the valleys underlain by the Inwood limestone. Most of the ground-water supplies in the County are obtained from the stratified drift and the underlying limestone—thus most of the wells for which records were obtained are in areas underlain by these materials. (See pls. 2 and 3.)

Ground water in the consolidated rocks.—The Inwood limestone is the most productive source of ground water among the pre-Cambrian rocks in Bronx County. The distribution of the formation is shown in plate 1. It crops out or is near the surface only in western Bronx and adjacent northern Manhattan. The formation is typically a gray to white coarsely crystalline, distinctly bedded limestone and dolomite which has been somewhat metamorphosed. The rock commonly disintegrates into a coarse calcareous sand. It is soluble in slightly acid water, thus making the formation less resistant to erosion than the other consolidated rocks. Widening of the joints and other fractures in the Inwood limestone by solution may result in the development of underground channels. Thus, because the formation is weak, it underlies low ground almost everywhere, and many of the navigable channels around Manhattan and Bronx are submerged valleys formed by the erosion in the rock. During the Pleistocene epoch, glacial melt-water streams occupied these low areas, and in part filled them with permeable stratified deposits, whereas the surrounding uplands were covered by relatively impermeable

till. The increased permeability due to solutional activities, and the presence of a permeable overburden that readily allows recharge, are the two factors that account for higher yields from the Inwood limestone than from the other consolidated rocks in the city.

Records were obtained for 18 wells in the Inwood limestone. The data are given in table 7, and the locations of the wells are shown on plate 3. The yields from these wells average 75 gallons per minute (gpm) and range from 1 to 300 gpm. The average depth of the wells is 340 feet and the range in depth is 70 to 1,800 feet. Although it is the most productive bedrock formation, in general the depth of wells are greater and yields smaller in the Inwood limestone than in the stratified glacial deposits of the County. Thus, for maximum yield, wells should be screened in the glacial deposits, where they are present. In a few places drillers have constructed wells which draw water simultaneously from both the stratified drift and the limestone. Yields of two wells constructed in this manner are 65 and 230 gpm, respectively. The quality of water obtained from the Inwood limestone is satisfactory for most industrial purposes although for some the water is too hard and alkaline. The average hardness and alkalinity in four analyses are 416 and 259 ppm, respectively.

The crystalline rocks in the County other than the Inwood limestone are relatively impermeable and yield only small quantities of water to wells. Although such yields are sufficient for domestic purposes, and are so used in other areas, they are of little value in New York City, where wells are used almost exclusively for industrial or public-supply purposes. The Manhattan schist, a hard dark-green to black micaceous rock underlying the entire eastern two-thirds of Bronx County, is considerably less productive than the Inwood limestone. Yields range from about 9 to 200 gpm, most reported yields being less than 50 gpm. Depths of wells penetrating the formation range from about 100 to 900 feet. The iron content in water from the Manhattan schist is generally somewhat higher than that in water from the Inwood limestone, but alkalinity and hardness are much lower. (See table 5.) Almost the entire supply of ground water in the rock is held in fractures which decrease in size and number with depth. Drilling to depths greater than about 300 feet is usually not advisable, if water has not been obtained at shallower depths.

The Fordham gneiss, a massive, coarsely crystalline black- and white-banded rock, underlies the areas of high relief in the western third of Bronx County. Records of only two wells penetrating the gneiss were collected for this report. These yield 5 and 35 gpm, respectively. No chemical analyses of water from this formation were obtained, but the quality probably is similar to that of water in the Manhattan schist.

Although most of the ground water in the County is from precipitation, a small amount of water is derived from other sources. For example, some ground water probably moves into northern Bronx County from Westchester County as underflow in the glacial deposits filling the northeast-trending valleys in the Inwood limestone, and some water may move into the County via solution channels in the limestone itself. However, most of the Bronx-Westchester boundary is underlain by relatively impermeable crystalline rocks (Fordham gneiss and Manhattan schist).

Another possible source of recharge of unknown amount is leakage from sewer and water lines. According to the annual report for 1950 of the Chief Engineer, the New York City Bureau of Water Supply stopped leaks from water mains in Bronx County which totaled about 14.4 mgd. This is about seven times the estimated pumpage of ground water for industrial use in the County. The leakage from sewers was not estimated.

Ground water in the unconsolidated deposits.—The unconsolidated deposits in Bronx County consist of upper Pleistocene deposits and Recent alluvium. It is believed that Cretaceous deposits were once present in the Bronx but have been removed by erosion. The glacial

deposits consist chiefly of till, deposited as ground moraine. The till is relatively thin and in places only incompletely blankets the bedrock. Because of its thinness (about 2 to 35 feet) and low permeability the till yields very little water to wells, and consequently it is of no practical importance as an aquifer in Bronx County.

Several deposits of stratified drift occur in the County, but only one is large enough to contain ground water in sufficient quantity for industrial or commercial use. This is a long, narrow body that extends south-southwestward across the County in the western part. (See easternmost of two outwash-filled valleys on pl. 2.) This deposit is roughly a quarter of a mile wide. It occupies a narrow valley that was formed in pre-Pleistocene time on the outcrop of the Inwood limestone. Upon the melting of the last glacier that covered the area, the valley was filled with stratified deposits.

The stratified drift consists mainly of sand and gravel and attains a maximum recorded thickness of 145 feet at well B10 [1] shown in plate 3. Records were obtained for a few wells penetrating the drift only, but of the 18 wells tapping the Inwood limestone for which records were obtained 12 are in areas overlain by thick stratified drift. The average yield from these 12 wells is 100 gpm, whereas the average yield of the other six wells tapping the limestone and covered by till or thin stratified drift is only 30 gpm. The permeable drift serves as a temporary reservoir and also readily allows the transmission of water to the underlying rock, whereas the relatively impermeable till that covers other areas impedes the downward movement of water to the rock beneath.

Recent alluvium is confined to the flood plains of the Bronx River and several other small streams. The alluvium is thin, limited in areal extent, and of no importance as an aquifer.

No records of wells or springs used for domestic purposes were obtained for this report in Bronx County. However, according to a compilation by Smith (1938) there were at least 300 such wells and springs in Manhattan and Bronx at the end of the 19th century. Most of these are now covered by streets and buildings or otherwise abandoned.

New York County (Manhattan)

Characteristics of the Water-Bearing Formations

Manhattan Island is underlain by pre-Cambrian metamorphic rocks which have been tightly folded, and subsequently eroded to form northeast-trending low hills and valleys which are most prominent in the northern half of Manhattan. (See pl. 1.) Northwest-trending major faults cross the island in the vicinity of 125th Street and of Dyckman Street in northern Manhattan. The rock beneath most of the County is the Manhattan schist. The Inwood limestone underlies two small areas in the northern half of the County and the surrounding tidal channels. In addition, a narrow belt of limestone also extends across the southeastern portion of the County near the East River. The Fordham gneiss crops out in a few places in the northern half of Manhattan, and it underlies several islands in the East River between Manhattan and Queens (not shown on pl. 1). At most places the pre-Cambrian rocks are overlain by a thin covering of Pleistocene deposits consisting chiefly of till. However, in at least two sizable areas (see pl. 2), significant thicknesses of stratified glacial deposits have accumulated in depressions on the bedrock.

Ground water in the consolidated rocks.—The Manhattan schist is a dark-gray to black micaceous rock composed of biotite, muscovite, quartz, feldspar, and smaller amounts of accessory minerals, and locally containing dikes and veins of pegmatitic material. The rock con-

[1] Wells in this report are identified by a letter and number. The numbers are repeated in each County. For example, wells R1, Ny1, and B1, are in Richmond, New York, and Bronx Counties, respectively. See tables 6 and 7 for data on these wells.

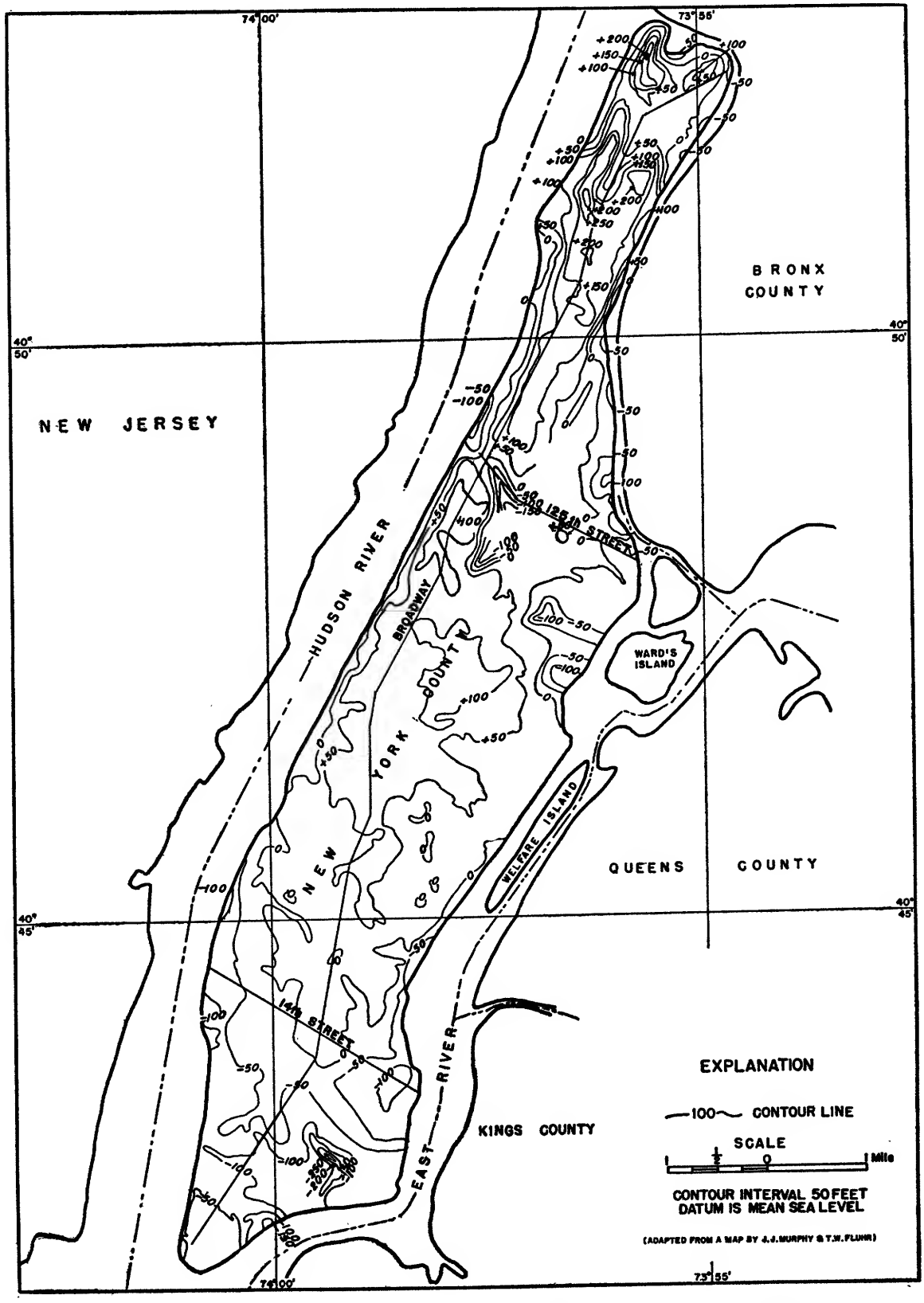

Figure 4.—Contours on the surface of the bedrock in New York County (Manhattan).

tains some joints, irregular fractures, and faults along which ground water moves, but in some places chemical weathering has filled these openings with clay, an end product of rock weathering. The formation is not considered to be an important source of ground water in Manhattan, as the data from drilling indicate that the schist generally does not yield enough water for industrial use. The average yield of 3 wells penetrating the formation is only 35 gpm, and the average depth is 370 feet. At a few places where the rock is intensely fractured and is overlain by water-bearing glacial deposits somewhat higher yields may be obtained. For example, at well Ny137, a yield of 70 gpm was obtained for air conditioning; however, the drawdown in the well was 305 feet.

The Manhattan schist underlies more than three-fourths of Manhattan and makes a varied topography, as indicated by the contour map, figure 4. Although not compiled by the Geological Survey, the map was included mainly to permit estimating the depth to bedrock in different parts of the County and is believed to be the best map available for that purpose. However, the authors of this report do not necessarily agree with all the details of the contouring. No attempt was made to modify the bedrock contours for this reconnaissance report. In another bedrock map compiled by Hobbs (1905), based on fewer data, the configuration of the bedrock surface differs considerably from figure 4, particularly in the delineation of the prominent depressions.

The depressions in the rock surface in southern Manhattan (bottom at about —250 feet), and in the north-central part of the island (bottom at about —175 feet) are filled with glacial deposits that contain most of the available ground water in the County. Their origin is not definitely known, but the depressions may have resulted from one, or combinations of several processes such as faulting, solution of limestone, and glacial erosion.

The northern depression, which according to figure 4 actually consists of several depressions having different depths, is apparently situated along a major fault zone which trends northwest across Manhattan from 96th Street and the East River to about 125th Street and the Hudson River.

Erosion of decayed and shattered rock along the fault zone may in part account for the depression. Also, much of the bedrock in the area of the northern depressions is the Inwood limestone, a rock in which solution channels, sinkholes, and caverns may develop. It is not unreasonable, therefore to suggest that solution of the limestone may have been a factor in producing the depressions. This suggestion is substantiated to some extent by the fact that isolated residual high areas within the general area of the northern depressions are underlain by crystalline rocks other than the Inwood limestone. Finally, scouring, overdeepening of decayed zones, and plucking of joint blocks by the ice presumably further modified the existing depressions which were later filled by stratified deposits of melt-water streams. A similar combination of processes may have produced the depressions in southern Manhattan but there is no evidence of a major fault in that area. Berkey (1910, p. 282) suggests that the depressions in southern Manhattan may be related to the preglacial channel of the East River. He points out that below 23rd Street the river is displaced to the east of the former channel and now flows over a relatively thin cover of drift above the rock floor. (See upper cross section, fig. 5.)

Because few wells take water from the Fordham gneiss or Inwood limestone in Manhattan, the water-bearing characteristics of those formations are discussed in more detail in the preceding section describing the geology of Bronx County, where more data are available. In Manhattan the characteristics of the rocks are probably about the same, and the Inwood limestone, particularly, might yield water for industrial purposes. Well Ny139, an 8-inch well 310 feet deep in the extreme northern part of Manhattan, yielded 50 gpm.

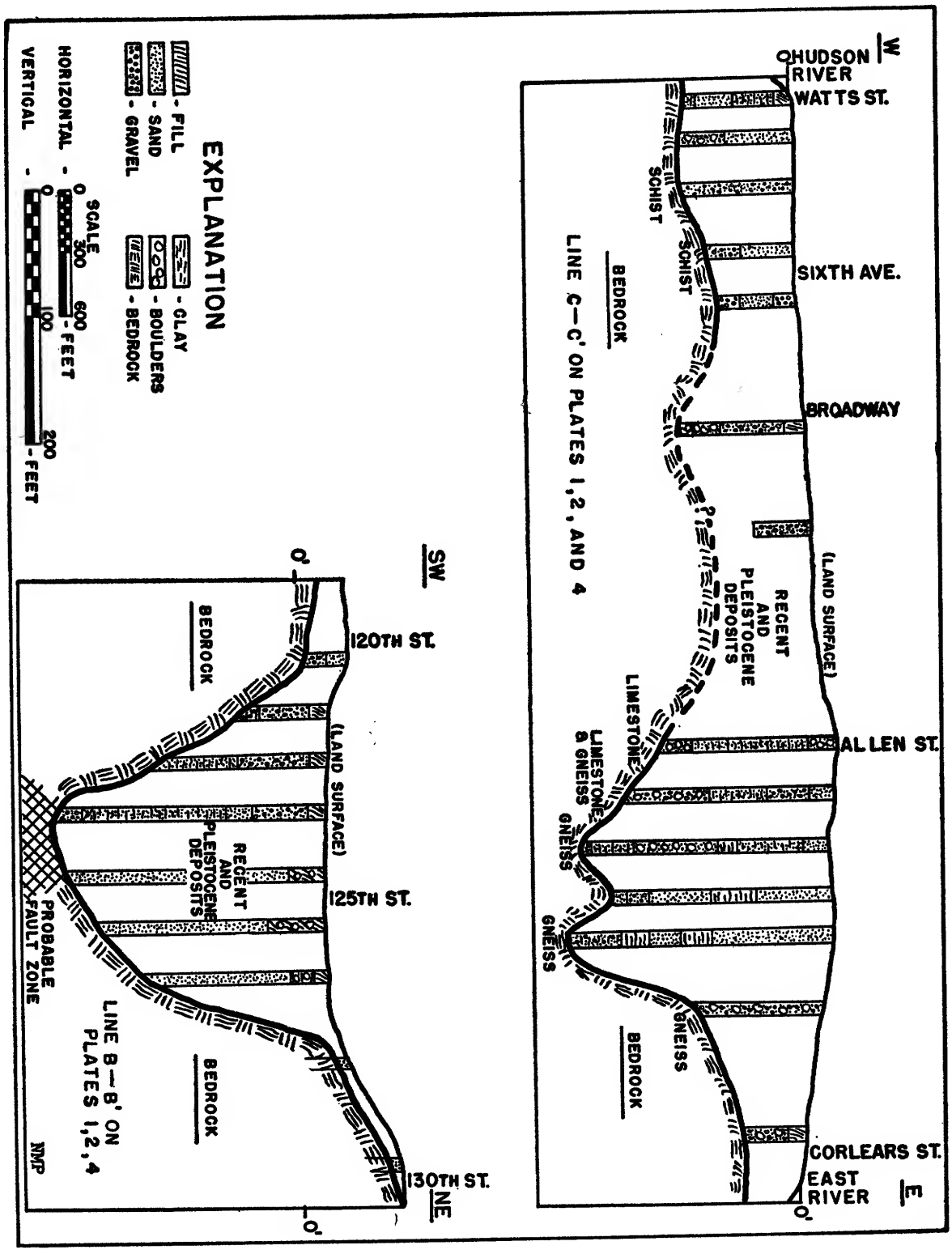

Figure 5.—Geologic sections in New York County.

Ground water in the unconsolidated deposits.—The unconsolidated deposits in Manhattan consist almost entirely of upper Pleistocene deposits. There are a few small deposits of Recent age in northern Manhattan and in the tidal channels bordering the County, but they have no practical value as sources of ground water.

As elsewhere, the Pleistocene deposits consist of till and stratified drift. The till was deposited as ground moraine, is less than 25 feet thick in most places, and is discontinuous. Because of its thinness and low permeability the till yields little water to wells, and as in Bronx County, is not a productive aquifer. However, two large bodies of stratified drift in Manhattan contain and yield considerable ground water. These bodies which are associated with the prominent depressions in the bedrock surface, are shown on plate 2, and their presence is indicated also on plate 4 by the concentration of wells at the southern end of the island and in the vicinity of 125th Street.

The smaller body is in the northern part of Manhattan and occupies a depressed area in the bedrock extending from 96th Street and the East River to about 145th Street and the Hudson River. The stratified drift in this area ranges in thickness from about 25 feet on the perimeter of the depressed area to as much as 175 feet in the deeper parts. It consists of sand, gravel, and clay; the lower cross section in figure 5 illustrates the varied lithology of the deposits in the northern depression. Records of seven wells screened in these deposits show an average well depth of 50 feet and an average yield, based on data from three wells, of about 60 gpm. Five of the wells have a chloride content of less than 50 ppm. However, heavy pumping in this area may result in contamination of the deposits, as they are open at both ends to salty tidal channels.

The second body of stratified drift in Manhattan that contains large amounts of ground water covers all the island south of 14th Street. The deposit consists mostly of sand, although beds of gravel and clay also are present. (See upper cross section in fig. 5.) The thickness of the stratified material averages about 100 feet and may be as much as 250 feet. Records of 58 wells tapping this body show an average depth of 57 feet and a range in depth from 18 to 160 feet. Of these wells, 47 have an average yield of 150 gpm; they range in yield from less than 10 to 500 gpm. Chemical analyses of water obtained at 34 wells in this area show a range in chloride content from less than 20 to more than 10,000 ppm. More than half the 34 wells yield water that has more than 100 ppm of chloride, thus suggesting that salt water has invaded the deposits.

The chemical analyses were made on samples collected over a period of 35 years, however, and many of them have little value in determining the present position of the fresh water-salt water boundary. As periodic analyses are available for only a few wells, it cannot be ascertained definitely whether the area of salt-water contamination is becoming more widespread, but the small amount of available evidence suggests increasing contamination, presumably from the tidal channels.

Chloride concentrations in southern Manhattan are highest in wells near the shoreline but some of the wells in the center of the island also show above-average concentrations. In 1949 ground-water pumpage in lower Manhattan reached a seasonal peak of almost 5 mgd. This pumpage is probably more than in earlier years. Also, recharge to the underground aquifers is limited to leakage from water mains (in 1950 the Bureau of Water Supply stopped leaks totaling about 6.4 mgd), of which a part must reach the edge of the island and seep out, and thus is not available to wells; to leakage from sewers (not estimated); and to the scant amount of rainfall that can infiltrate through the few parks and other open areas in the County. Therefore, the relatively high chloride contents are probably from infiltration of salt water resulting from excess of draft over replenishment.

In summary, more than 90 percent of the wells for which records were obtained in Man-

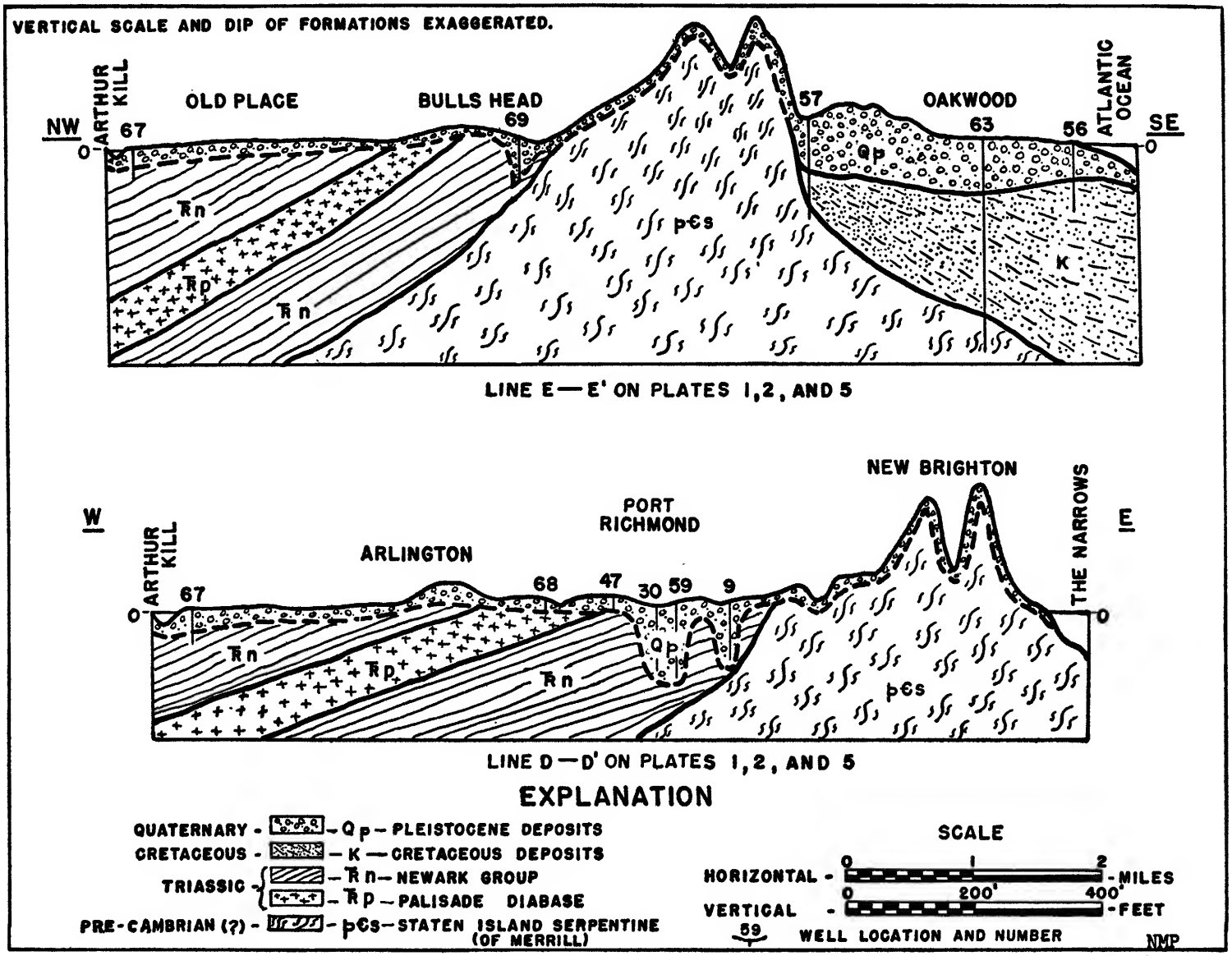

Figure 6.—Geologic sections in Richmond County.

hattan are concentrated in the two areas of stratified drift described above, and these are essentially the only areas on the island from which reliable supplies of ground water large enough for industrial or commercial purposes can be obtained. It should be borne in mind that continued or increased pumping will draw in salt water from the tidal channels, so long as an unfavorable balance exists between pumpage and replenishment.

Richmond County (Staten Island)

Characteristics of the Water-Bearing Formations

The basement rocks of Richmond County are pre-Cambrian metamorphic rocks. There are few records of wells penetrating the rocks, and they are regarded as essentially non-water-bearing. However, they are flanked on the northwest by consolidated sedimentary and igneous rocks of Triassic age which dip northwest, and on the southeast and south by unconsolidated Coastal Plain sediments of Cretaceous age which dip toward the southeast and in part are water bearing. During Pleistocene time these formations were covered by glacial deposits. Figure 6 shows generalized geologic sections which illustrate diagrammatically the subsurface relation between these formations. With respect to the occurrence of ground water, the formations of Staten Island are divided into consolidated rocks which include serpentine, schist, gneiss, sandstone, shale, and diabase, and unconsolidated deposits which consist of gravel, sand, silt, and clay. Plate 5 shows the location of wells and test borings in Richmond County, and tables 6 and 7 give the data available for each well.

Ground water in the consolidated rocks.—Igneous and sedimentary rocks of Triassic age underlie the glacial deposits in the northern and northwestern parts of Richmond and, on the basis of information from New Jersey, probably dip about 10° to 18° to the northwest. The sedimentary rocks, known as the Newark group (pl. 1), consist of reddish-brown medium to coarse sandstone, and shale. The igneous rocks consist of a thick sill of diabase, within the sedimentary series. It apparently is an extension of the rock that forms the Palisades cliffs along the west shore of the Hudson River in New Jersey but is not a conspicuous topographic feature in Richmond.

The yields of wells penetrating the consolidated rocks generally are small. However, where permeable glacial deposits overlie the bedrock, the yield from rock wells is much greater. The rocks of Triassic age yield water from openings along bedding, joint, and fault planes. The water-bearing fractures decrease in number and size with depth, and therefore it generally has been found that no appreciable increase in yield results from drilling wells to a depth greater than about 300 feet. Drilling experience in adjacent areas indicates that the Palisade diabase is not a good aquifer, but in some places it may provide enough water for domestic needs. The record of well R47 (pl. 5) in Richmond indicates that a yield of only ½ gpm was obtained from the diabase before the well was abandoned. A low yield (less than 2 gpm) was obtained at R48, a well that taps the sandstone. These few data are not necessarily representative of the potential yield of the Triassic rocks. Wells that draw water from the Newark group in New Jersey and Rockland County, N. Y., have an average yield of about 75 gpm and individually as much as 700 gpm. Whether comparable yields can be obtained from the equivalent rocks in northern Richmond is not known. However, the limited area of recharge and the thinness of the glacial overburden makes it unlikely that large withdrawals of ground water can be made from the Triassic rocks in Richmond County.

The Staten Island serpentine of Merrill (1898, pp. 21-31) underlies the high areas in the northeast and central parts of the County and crops out in a few places. The serpentine is a dense, waxy-looking rock, ranging from dark green to mottled brown depending upon the degree of weathering. In many outcrops the rock contains numerous fractures and crumbles

readily. Records of five wells that penetrate the serpentine were obtained. The range in yield is ½ to 14 gpm and the average yield is 5 gpm. The depth of these wells ranges from 148 to 600 feet, and averages about 300 feet. According to Ellison (1949, p. 90), 17 out of 20 ground- and surface-water samples from areas associated with the serpentine showed high concentrations of magnesium and of silica.

Schist and gneiss have been penetrated in at least two places on Staten Island according to the logs of test borings and examinations of the material by geologists. Records for these borings (R42 and R57) are given in tables 6 and 7. Gratacap (1904, p. 171) reports also that schist was encountered during blasting for ferry slips at St. George. No ground-water significance is attached to the occurrence of these rocks. Yields from wells penetrating them probably would be no greater than yields obtained from the serpentine.

Ground water in the unconsolidated deposits.—The two principal groups of unconsolidated deposits in Richmond County are the deposits of Cretaceous and Pleistocene age. The beds of Cretaceous age are thought to represent the Raritan formation which crops out to the southwest in the type area in New Jersey. In Long Island the Raritan formation has been identified mainly on the basis of plant fossils and lithology and has been divided into the basal Lloyd sand member and the clay member. Because few drillers' logs and samples from wells completely penetrating the Cretaceous beds of Staten Island were obtained, it was not considered feasible to attempt a similar subdivision in Staten Island. Outcrops of Cretaceous beds are few and are confined to southwestern Richmond. Gratacap (1904, pp. 175-180) describes a clay deposit at Kreisherville containing lignite, pyrite, and leaf impressions. Cretaceous formations younger than the Raritan formation may be present in Staten Island but no direct supporting evidence is available. In this report, therefore, all the beds of Cretaceous age on Staten Island are referred to by their general age designation.

The Cretaceous deposits in Richmond consist of layers of clay, silt, sandy clay, sand, and gravel. Colors are white, gray, brown, red, and black. The sand consists chiefly of angular grains of quartz, clear, milky, or rusty in color, plus a small percentage of muscovite, kaolin, chert, and dark heavy minerals. Water-bearing zones occur at several depths, but insufficient data are available to determine whether they have any extensive lateral continuity. At some places, according to the well records, the Cretaceous deposits contain sandy zones up to 50 feet thick. Elsewhere two or three water-bearing zones 10 to 20 feet thick each are present. In still other areas the Cretaceous beds are predominantly clayey and completely lacking in water-bearing zones of significant thickness. Table 6 (Richmond County) gives detailed descriptions of the Cretaceous beds penetrated by several wells. The maximum thickness of the deposits is about 300 feet. The beds dip southeast and lie unconformably on a southeasterly sloping platform of impermeable bedrock, which according to the meager data has a gradient of more than 100 feet per mile.

The water-bearing zones of the Cretaceous deposits contain water under artesian pressure. In areas where the water table is above the piezometric levels of the deeper aquifers recharge takes place by downward percolation of water through the Pleistocene deposits, which almost completely blanket the Cretaceous beds. Yields from wells screened in the Cretaceous deposits range from about 50 to 300 gpm and average about 150 gpm. Except for a high iron content, water from the Cretaceous beds is of good quality. Similarly, the water from the Lloyd sand member of the Raritan formation in Long Island has a relatively high iron content.

The recharge area of the Cretaceous beds on Staten Island is of limited extent—no larger and, in effect, probably somewhat smaller than the area shown on plate 1—and there is a potential danger of salt-water intrusion if the beds are overpumped. However, higher yields might be obtained from these deposits by greater utilization of modern methods of well drilling and development.

The deposits of Pleistocene age in Richmond comprise four different types: ground moraine, terminal moraine, outwash-plain deposits, and valley fill. The outwash-plain deposits are the chief source of ground water. Plate 2 gives the distribution of the ground moraine, terminal moraine, and outwash-plain deposits. The valley-fill deposits, which occur in small areas in northern Richmond, are covered by the ground moraine and are identified solely from well logs.

The ground moraine is composed of reddish-brown clayey till derived chiefly from the shale and sandstone of Triassic age. It overlies almost the entire area north and west of the terminal moraine, including part of the highland formed by serpentine and most of the area of Triassic rocks. In some areas it covers stratified outwash deposits. The thickness ranges from about 10 to 85 feet and averages about 35 feet. The ground moraine is poorly sorted material having substantial amounts of clay and hence has a low permeability. It rarely yields more than 3 or 4 gpm to large-diameter dug wells.

The terminal moraine forms an irregular ridge extending from Stapleton on the northeast to Tottenville on the southwest. It continues into New Jersey beyond the Arthur Kill. It is similar in composition to the till deposits of the ground moraine but is usually thicker, and its irregular surface has higher relief. The terminal moraine is composed chiefly of a reddish-brown mixture of clay and sand, with boulders of sandstone, trap-rock (diabase and basalt), granite, and gneiss. It has a known maximum thickness of about 75 feet but probably averages much less. In a few places in the terminal moraine lenses of water-bearing sand and gravel up to 15 feet thick contain perched water bodies. Water from the terminal moraine deposits is best obtained by means of large-diameter dug wells but none of the wells have large yields. The quality of the water is generally satisfactory but danger of bacteriological contamination is great unless proper sanitary precautions are taken.

Outwash deposits, consisting chiefly of permeable beds of sand and gravel, form a gently sloping plain extending from the terminal moraine to the shoreline in the southeastern part of the island. The deposits are reddish brown to gray and are composed of particles of iron-stained quartz, brown sandstone, shale, arkose, diabase schist, granite gneiss, serpentine, biotite, and a variety of dark heavy minerals. A few well records indicate that some outwash material is present beneath the terminal moraine. This suggests either partial overriding of a newly formed outwash plain by advancing glaciers during the Wisconsin stage, or the presence of an earlier outwash deposit such as the Manhasset formation in Long Island (Fuller, 1914, p. 115). Although the outwash deposits consist chiefly of coarse-grained materials, in a few places in the northeastern part of the outwast plain layers of sandy clay and solid clay ranging in thickness from 2 to 12 feet are present. The clay layers are generally underlain by beds of coarse sand and gravel, the whole sequence being somewhat similar to the Gardiners clay and Jameco gravel in Kings and Queens Counties. However, pending further collection of data and examination of samples, the sequence has not been differentiated and is included with the outwash deposits in this report. The outwash deposits have a known maximum thickness of about 90 feet.

Water-table conditions prevail throughout the outwash deposits except perhaps locally beneath some of the clay layers mentioned above. Most of the public-supply wells in the municipal well fields (table 3) appear to be screened entirely in the outwash-plain deposits. In several of the wells, where clay layers are present, screens have been installed at two depths, one section above and the other section below the clay layers. When first tested in 1912, the wells in the Hylan Boulevard fields (pl. 5) had individual yields ranging from 40 to 700 gpm. As the wells in each field now discharge into common suction lines, only data for combined yields from each well field can be obtained (table 3). In 1950, Hylan Boulevard (Auxiliary) well fields 1, 3, and 4 and the Grant City well field (pl. 5) were shut down owing to an increase in

chloride content. Boulevard well field 2 operated throughout the year with no unusual rise in chloride content, and more than 2 mgd has been pumped from the Bulls Head well field with no significant change in chloride content.

There is a small area of outwash in northwestern Richmond also, but not much is known about these deposits. Records from two test borings (R67 and R83) indicate that they consist of beds of fine sand, silt, and gravel, and are as much as 48 feet thick.

Valley-fill deposits are present in several parts of northern Staten Island such as the Bulls Head and Port Richmond areas, where layers of sand and gravel were deposited by glacial melt-water streams in preglacial valleys cut into bedrock by north-flowing streams. At well R59 (pl. 5) in northern Staten Island the valley fill is at least 105 feet thick and consists of stratified deposits of clay, silt, sand, and gravel. In this well the coarse-grained material is at the bottom. The buried valleys are potential sources of ground water in the Port Richmond area, and if the log of well R59 is representative the deepest parts of the valleys may contain productive deposits. Figure 6 shows the location and cross sections of two buried valleys in northern Staten Island. Additional data are needed to determine the full extent and depth of these and other valleys. The average yield of wells in the Port Richmond valley is about 250 gpm. It should be borne in mind that the buried valleys in the Port Richmond-West New Brighton area, which are bordered on the north by Kill Van Kull, are readily accessible to salt-water intrusion; and a public-supply well field at West Brighton was abandoned more than 30 years ago apparently because of salt-water contamination.

Although the Cretaceous beds in southwestern Richmond may be continuous with beds of the same age in New Jersey (pl. 1), no evidence exists of substantial movement of fresh ground water between the two areas. If the sediments beneath Arthur Kill, a tidal channel separating Richmond from New Jersey, are permeable, ground water presumably moves toward the Kill both from New Jersey and from Richmond and there leaks vertically upward. Such leakage would mean that there could be no movement of fresh water across the State line in either direction, at least in the beds affected by it. It is conceivable that southeastward movement could occur beneath Arthur Kill in the deepest Cretaceous beds, while water leaked into the Kill from the upper beds on both sides of the Kill. No evidence is available in this regard, however, and the safest assumption is that developments in Richmond must depend entirely on local recharge. Too, even if southeastward movement beneath the Kill occurs under natural conditions, there is the possibility that heavy pumping in the Cretaceous beds near Arthur Kill may cause salt-water intrusion, as has already occurred locally to the west in New Jersey. The same danger exists so far as the Pleistocene strata are concerned, of course.

The buried valley of the Hudson River probably separates the deposits of Cretaceous age in eastern Richmond from those in Long Island. With respect to the movement of ground

Table 3.—Data on municipal well fields in Richmond County, 1950
(All wells tap upper Pleistocene deposits)

Well field	Number of wells	Range in depth of wells (ft.)	Average pumpage [1] in 1950 (mgd)
Bulls Head	30	50-80	0.6
Grant City	17	50-100	.0
Boulevard No. 1[2]	14	75	1.1
Boulevard No. 2	14	75-100 (?)	2.3
Boulevard No. 3	14	75-100 (?)	.6
Boulevard No. 4	14	75-100 (?)	1.7

[1] Wells owned by New York City are generally operated several months a year.
[2] Boulevard well fields referred to also as Auxiliary 1, 2, etc.

water, the basic questions are, first, whether this buried valley trenches the Cretaceous deposits, in which case of course it would cut through any younger water-bearing formations, and second, whether the fill in the valley, regardless of geologic age, is permeable enough to transmit water.

By projecting bedrock contours between Richmond (Veatch, 1904, pl. 1) and Kings Counties (deLaguna and Brashears, 1948, pl. 1) it can be seen that the bedrock surface probably lies between 100 and 400 feet below sea level beneath the Hudson River where it passes between the two Counties at the Narrows. This is sufficiently shallow so that the buried valley probably cuts through all or most of the Cretaceous deposits and any overlying beds that were deposited before the buried valley was formed; and at least in the northern part of the Narrows it may notch the bedrock itself. This supposition is based in part on data from test borings, and in part on the theory, advanced by many geologists, that sea level was perhaps 250 to 350 feet below present sea level during part of the Pleistocene epoch. For example, some test borings for a tunnel across the Hudson River opposite 32d Street, Manhattan (Berkey, 1933, pl. 8), penetrated to a depth of about 300 feet below sea level, near the center of the present channel, without encountering bedrock. As this locality is about 10 miles upstream from the Narrows, a slight southward gradient of the valley would place the bedrock surface at the Narrows appreciably deeper than 300 feet below sea level. Thus, depending on the permeability of the post-valley fill, ground water in the Cretaceous aquifers may escape into the river from both Richmond and Kings.

There is little information on the nature and age of the fill in the buried valley of the Hudson River. The valley must have been formed before the latest glacial stages, and probably prior to the deposition of the Jameco gravel, but direct evidence is lacking. According to a cross section provided by the New York City Transit Authority, based on test borings for a tunnel between Richmond and Brooklyn, the maximum depth of water at the Narrows is about 100 feet and the underlying deposits are chiefly fine sand, silt, and clay, containing shells, presumably of late Pleistocene and Recent age. These deposits extend to a depth of at least 30 feet below the river bottom. The deepest boring shown on the cross section penetrated only to about 130 feet below sea level. Near the Staten Island shore the deposits consist almost entirely of sand and gravel. In contrast, near the Brooklyn shore, the deposits are mainly clay.

A more detailed cross section of the valley fill at the site of the 32d Street tunnel between Manhattan and Weehawken, New Jersey probably provides a clue to the type of material that may occur at depth in the Narrows. At that site the material to a depth of 150 feet below sea level consists of mud, clay, and silt, mostly of Recent but perhaps in part of late Pleistocene age; beneath this are beds of blue clay, silt, and sand, 50 to 125 feet thick; and at the bottom, directly on bedrock, is 25 to 50 feet of gravel and coarse sand. The blue clay underlain by sand and gravel suggest the Gardiners clay and Jameco gravel sequence described in Kings and Queens Counties by Veatch (1906), Fuller (1914), and others.

Although most of the deposits overlying the lowermost beds of gravel in the channel at this section are relatively impermeable, they consist in part of silt and sand, and the clay beds may be discontinuous. Thus, doubtless leakage through them can take place in the vertical direction. In addition, lateral movement may occur in the lower beds of gravel. Therefore, if the buried channel in the Narrows is filled with sediments similar to those found farther north, it would provide a potential zone for ground-water movement; the direction of movement depending on head relationships. If the piezometric surfaces of the aquifers in Richmond and Kings Counties slope toward the channel, fresh ground water can escape by discharging into the lower gravel deposits and then moving slowly upward through the overlying silt and clay; or by flowing laterally in the gravel to a place where vertical leakage can occur. However, if the hydraulic gradients are reversed by heavy pumping near the shoreline in either County, the salty water of the bay could move into the aquifers.

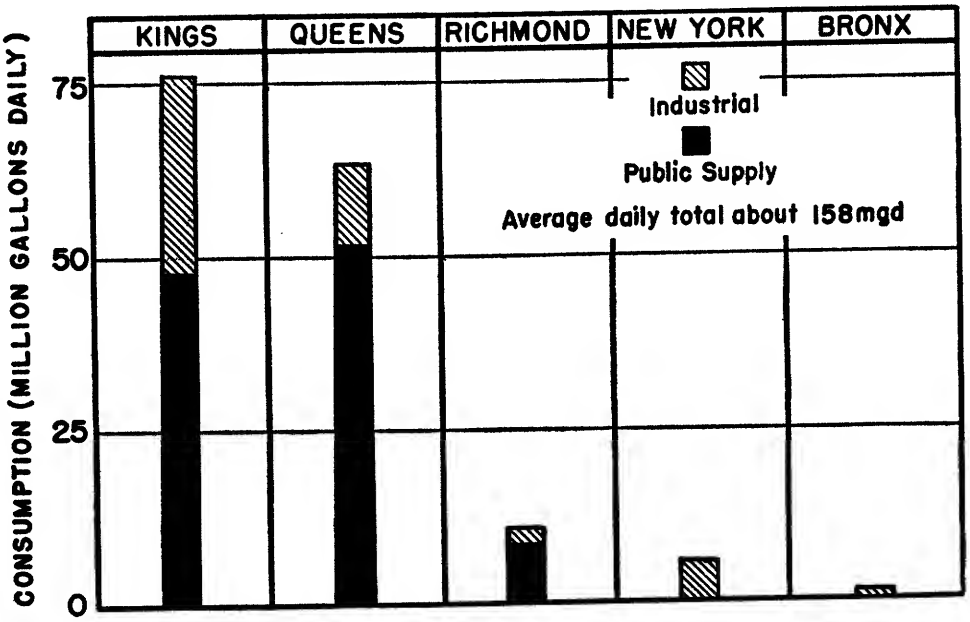

Figure 7A.—Average daily consumption of ground water in New York City, 1949.

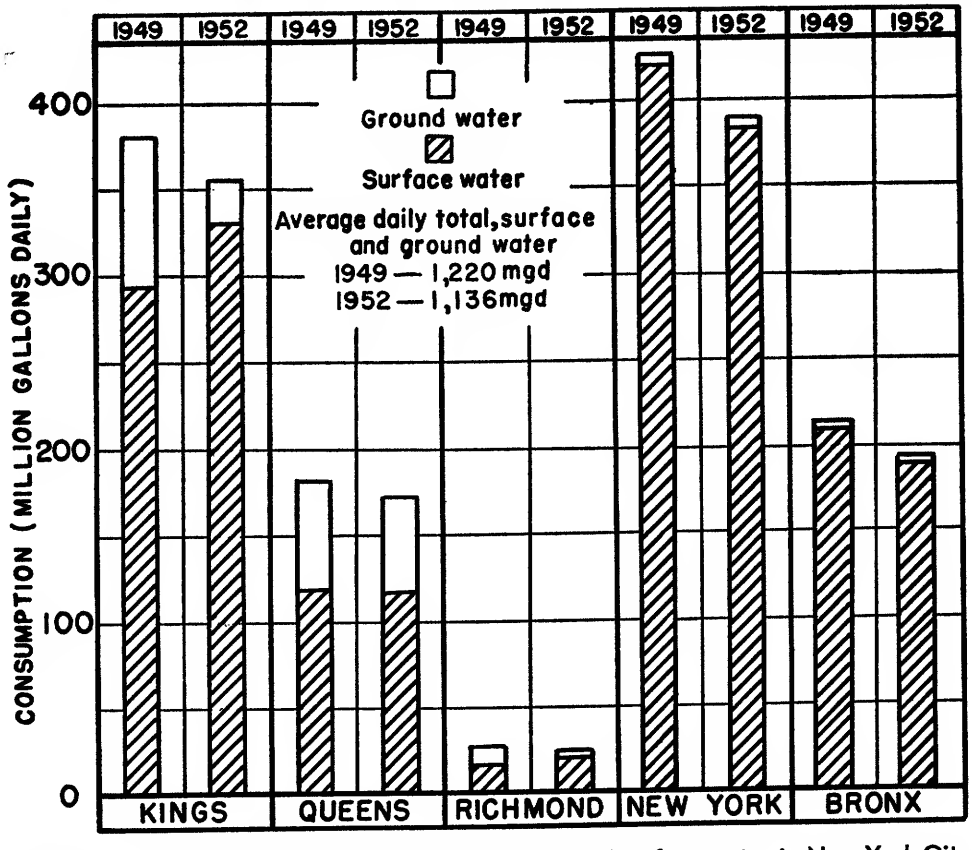

Figure 7B.—Average daily consumption of ground and surface water in New York City in 1949 and 1952.

The sea-bottom expression of the Hudson channel has been mapped in great detail (Veatch and Smith, 1939) from the vicinity of Sandy Hook, N. J. southeastward for about 115 miles to the edge of the continental shelf where it apparently terminates in a spectacular gorge or canyon the bottom of which is about 7,000 feet below sea level. For a discussion of the origin of the gorge the reader is referred to Johnson (1939), Shepard (1948, chap. 5), and Kuenen (1950, chap. 7).

With respect to future ground-water developments, probably the only part of Richmond from which additional substantial amounts of ground water for industrial or public-supply uses can be obtained is in an area of about 30 square miles in southern Richmond, roughly bounded by Arthur Kill and Richmond Roads on the northwest and the shoreline on the southeast. The geologic conditions in that area appear to be favorable for artificial recharge of ground water, as the area is underlain by several hundred feet of relatively permeable Cretaceous and Pleistocene deposits, which could be recharged by means of wells, basins, ponds or ditches. Water for such a purpose might be available from municipal surface-water sources, particularly when the upstate reservoirs are full.

UTILIZATION

The water from most of the wells in New York City is used by industrial plants or commercial establishments. Public-supply wells are relatively few in number but the pumpage from them generally is about 50 percent of all ground water pumped in New York City. A few wells furnish water for domestic use in all Counties except New York, but the total pumpage from these wells is insignificant. The amount of ground water consumed for industrial or public-supply use differs considerably in each of the Counties (fig. 7A). It also varies from year to year, depending to some extent on the amount of precipitation which affects the quantity of water in storage in the city's upstate reservoirs. Consequently, when surface supplies are low, the deficiency is overcome in part by increased ground-water pumpage. The comparison of consumption between dry and wet years is given in figure 7B which shows the metered and estimated average daily consumption (surface and ground water) for a year of low rainfall (1949—34.70 inches) and a year of high rainfall (1952—46.71 inches). It should be understood that not all of the ground water consumed in Kings and Queens actually is pumped from aquifers in those Counties. During certain years part of the public supply in the two Counties is obtained from ground-water ponds and wells in Nassau County owned by New York City. Furthermore, in constructing the graphs for 1952 (fig. 7B), it was assumed that the industrial ground-water pumpage in Bronx, Richmond, and New York Counties had not changed appreciably from 1949 to 1952. This seemed reasonable as the decline in the use of ground water from the period of high consumption (1949-50) was probably largely balanced by the pumpage from new wells constructed since that time.

Descriptions of the regulation, history, and use of ground water for industrial and public-supply purposes in each of the Counties are given in the sections that follow.

Regulation of Ground-Water Withdrawal and Use

The withdrawal and use of water from wells in New York City are subject to some regulation by the New York City Department of Health and the New York State Water Power and Control Commission but the regulations do not apply uniformly throughout the city. The Sanitary Code of the Department of Health prohibits the use of water from wells, except by a city agency, in all the Counties for any purpose, on any premises, without a permit. Water from wells in Manhattan cannot be used for drinking purposes, but a permit may be issued for wells supplying water for other than drinking purposes. In the other four Counties well water may

be used for all purposes after a permit is obtained, an analysis of the water has been made by the Department of Health, and sanitary requirements have been met.

The Water Power and Control Commission has jurisdiction over the taking of sources (both surface and ground water) for public water supply throughout the State. Also, on Long Island, the Commission is authorized to regulate well drilling and withdrawal of ground water for industrial, commercial, and air-conditioning use. Well drillers do not have to secure permits or licenses from the Commission to operate in Bronx, New York, and Richmond Counties, but in Kings and Queens Counties, on Long Island, a driller must be licensed, must have a permit to drill, and must make certain reports to the Commission upon completion of a well.

Industrial Pumpage

The withdrawal of ground water from privately owned wells for industrial purposes increased during the last quarter of a century and is now at a maximum. The continuance of this practice, in spite of the availability of public supplies, is because (1) industrial plants require large quantities of water, and over a period of years the cost of constructing and operating a well may be much less than that of purchasing water from a public supply, and (2) for cooling or air conditioning, ground water, with its constant temperature, is more satisfactory than surface water with its variable temperature which in summer is higher than that of ground water.

The industrial ground-water pumpage and recharge (see beyond) in New York City in 1949 is summarized by Counties in Table 4.

Table 4.—Industrial pumpage, in millions of gallons per day in New York City, 1949

County	Bronx	New York	Richmond	Kings	Queens	Total
Number of plants	11	65	23	254	140	493
Industrial pumpage (mgd)	1.7	6.5	2.2	31	12	53.4
Number of recharge wells	a	a	a	192	142	334 +
Industrial pumpage recharged (mgd)	a	a	a	9.9	4.9	14.8+

a. Data not available, probably negligible.

In Kings and Queens Counties, where drillers are required to submit detailed well-completion reports to the New York State Water Power and Control Commission, almost complete coverage of industrial pumpage data was obtained. The figures for industrial pumpage and recharge are annual means; they include both meter records and estimates based on pump capacity and numbers of hours of operation. The figures for Bronx, New York, and Richmond Counties are estimated peak seasonal means and therefore, the totals may seem to be too high. However, these data do not represent full coverage, as time did not permit a complete well or pumpage inventory in these Counties. It is estimated also that there may be an additional peak pumpage of at least 2 mgd in the three Counties. Thus, although the total pumpage figures given in table 4 may be thought to be too high, the error due to this assumption is probably small, presumably being balanced by the incompleteness of the pumpage inventory.

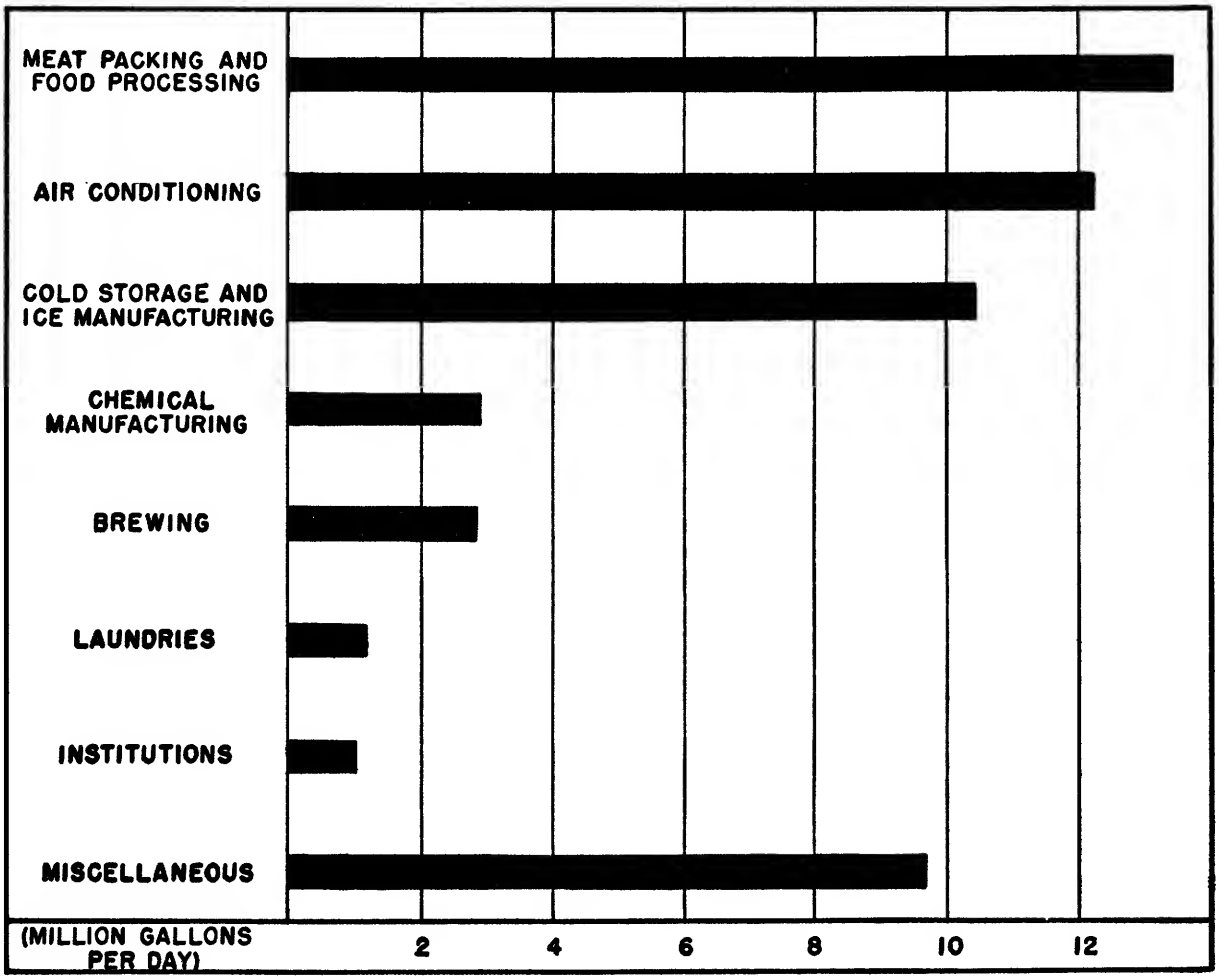

Figure 8.—Use of ground water by industries in New York City, 1949.

Figure 8 shows graphically the industrial pumpage in New York City by type of industry and use. It must be kept in mind that this breakdown is based on incomplete data for Bronx, New York, and Richmond Counties. Data for Kings and Queens were supplied by the Water Power and Control Commission.

One of the largest uses of ground water in New York City is for air conditioning. Because much of the ground water pumped for air-conditioning or cooling purposes moves through a closed system and, except for a variation in temperature, is generally not changed chemically or contaminated, it can be used to recharge artificially the aquifer from which it is pumped. Recharge can be accomplished by means of pits, basins, or wells. Experience in Kings and Queens Counties, where the Water Power Control Commission requires that water pumped from new cooling or air-conditioning wells having a capacity of more than 45 gpm be returned to the aquifer from which it is drawn, has shown this to be a practical method of maintaining water levels. In accordance with the requirement, an average of 14.8 mgd was recharged in 1949 by industries in Kings and Queens Counties. This amount is substantial; it is half again as much as the estimated combined industrial pumpage in the other three Counties (see table 4). As a similar requirement does not exist in those Counties, no recharge data were obtained for them, but there are probably a few recharge wells in each County. More widespread use of

recharge methods, wherever feasible, by industries in Manhattan, Richmond, and Bronx may aid substantially in preventing excessive lowering of water levels and subsequent salt-water intrusion.

Public Water Supplies

History of the Public Water-Supply Systems in New York City

Water from wells and springs has been used as a source of supply since the time of the first settlements in New York City. The withdrawal of ground water from privately owned wells for domestic purposes, however, gradually diminished as the area served by public systems increased. Today the entire city is served by the municipal system from surface- and ground-water sources, except for areas in Queens supplied by two privately owned public-supply systems using wells. Only a few privately owned wells now furnish water for domestic uses in parts of Richmond, Bronx, Kings, and Queen Counties.

The first public water supply in New York City was from ground water and since that time at least a small part of the city supply has been from ground-water sources. However, whereas these sources were important in the early history of the city, in 1949, a year of low rainfall, they furnished about 9 percent of the total consumption from public-supply systems. In 1952, only about 4 percent of the total public supply was from ground-water sources (see figs. 7A and B).

The first public well in New York City was dug in front of the old fort at Bowling Green in southern Manhattan, about 1677. Additional public wells were drilled in the streets from time to time as required, the city bearing part of the expense and the property benefited bearing part. The first truly municipal supply was constructed in 1799 when the population of the city was 60,000 (Merchants Assoc. 1900, p. 108). The source was a dug well, 30 feet in diameter, in Centre Street, Manhattan. The water was pumped to a storage tank on Chambers Street, from which it was distributed through pipes made of bored logs. From this time on the municipal supply in New York City barely managed to keep one jump ahead of the rapidly increasing population. By 1835 the city had constructed several additional wells and in addition, was importing water from the surrounding communities. At that time it was decided that ground-water sources alone would not be sufficient to supply the city, and a plan to procure water from the Croton River in Westchester County was adopted. By 1842 the city was being supplied through the Croton Aqueduct. In 1905 the entire practicable yield of the Croton watershed was being used by the city and, in addition, water was being taken from the Bronx and Byram Rivers as well as a considerable quantity from wells and local ponds. By 1917 the Catskill system was in use, and in 1944 water was brought into the city from the Rondout watershed in upstate New York, a distance of about 85 miles.

Prior to 1898 the development of public water supplies in Bronx and Richmond Counties, as well as in Kings and Queens, proceeded independently from that for Manhattan. In 1859 a municipal system taking water from ponds and streams on the south shore of Long Island provided the first public supply in Kings County (formerly the City of Brooklyn). The yield of surface water was later supplemented by water obtained from wells, the whole assembly being known as the Ridgewood system. In addition, several private companies in Kings County furnished water drawn from wells. Public supplies in Bronx and Richmond Counties, as well as Queens, were privately owned except for parts of the Bronx that were supplied by city water; and the water was obtained almost exclusively from wells. After consolidation of the city into five boroughs in 1898, the private companies were gradually acquired by the city, and

today only two private water companies exist in the city, in Queens County. These two companies (Jamaica Water Supply Co. and New York Water Service Corp.) pumped about 39.9 mgd in the southern half of Queens County in 1952.

The public water supply of New York City at the present time is obtained from the Croton watershed, the Bronx and Byram watersheds, the Schoharie and Esopus watersheds (Catskill system), and the Rondout watershed; from city-owned wells in Richmond, Queens, and Nassau Counties; and from privately owned wells in Queens County, the aggregate safe yield being about 1,120 mgd according to the New York City Board of Water Supply. Additional detailed information on these systems is given in U. S. Geol. Survey Circular 283 (see Lohr, and others, 1952, p. 8). Water will be obtained also from facilities in the Neversink watershed by 1954 and the East Branch watershed by 1956, these being in the Delaware system now under construction. The total estimated yield of the New York City municipal supply after this part of the Delaware system is completed is about 1,545 mgd. This includes about 85 mgd from ground-water sources in Long Island and Richmond. In addition, for use until the projects now under construction on the Delaware system are completed and put into operation, the city has emergency facilities for taking 100 million gallons per day from the Hudson River at Chelsea, about 10 miles below Poughkeepsie. This emergency source must be discontinued by January 1, 1957, unless the city has applied to and secured the approval of the New York State Water Power and Control Commission for an extension of that date.

Pumpage for Public Supply

There is no withdrawal of ground water for public supply in Bronx County at the present time and there are no records indicating that any appreciable amount was ever pumped. Bronx is now supplied entirely with surface water from upstate sources. Similarly, no ground water has been pumped for public supply in Manhattan since 1842 when Croton water was first made available. Since that time the public water supply for Manhattan also has consisted entirely of surface water supplied from the upstate sources of the municipal system.

Only in Richmond, Kings, and Queens Counties has ground-water pumpage represented an appreciable portion of the total amount of water pumped for public supply in recent decades. Figure 9 is a comparison of the average daily withdrawals in these Counties from 1905 to 1952. The curves are based on the total withdrawals from both municipal and private systems. The marked decline in ground-water pumpage in all Counties in 1917 and for several years afterward is attributable to the introduction of water from upstate surface sources (Catskill system), and the almost complete shutdown of the municipal ground-water facilities.

Pumping by private companies in Richmond County ceased completely in 1917 when the city acquired the last of the private water companies (South Shore Water Works Co.). Since that time pumping by the New York City system in Richmond has been sporadic. Between 1924 and 1948 the pumpage averaged less than 8 mgd, except in 1931. In 1949 an extra burden was placed on the Richmond wells owing to the water shortage in the upstate surface-water systems, and for the first time in 25 years the pumpage exceeded 8 mgd. At present Richmond is supplied with water from upstate surface sources and some ground water from the municipal well fields in the County. In 1949, for example, about 8.3 mgd or 33 percent of the average consumption of 25 mgd was from ground-water sources in Richmond. In contrast, during 1952, a year of high rainfall, only about 4 percent (0.9 mgd) of the pumpage for public supply was from wells.

The city-owned wells in both Richmond and Long Island are operated only when need arises. In general the wells are pumped when the storage in the upstate reservoirs falls below 70 percent of capacity.

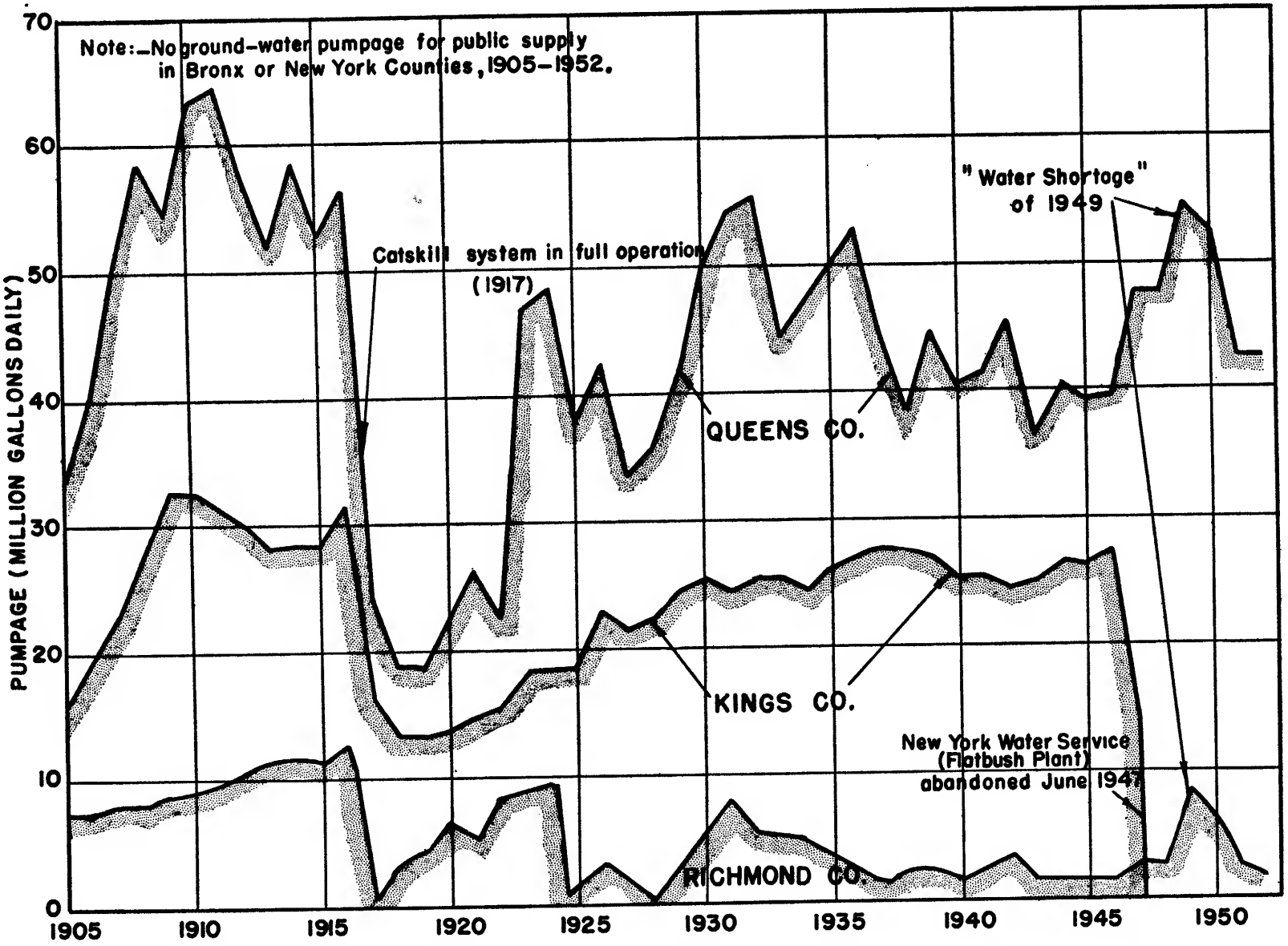

Figure 9.—Comparison of average daily withdrawal of ground water for public supply, by Counties, 1905-52.

As the pumpage from private systems in Richmond declined in the early 1900's and ceased in 1917, pumpage from the municipal system increased to some extent. In contrast, pumpage from private ground-water systems in Kings County, after surpassing the output from the municipal system in 1912, reached a peak of about 28 mgd in 1937 and then declined to zero in 1947 when the city required the cessation of further withdrawals by the New York Water Service Corp. After 1917, pumpage from the municipal system in Kings County was negligible. Since June, 1947, there have been no withdrawals of ground water in Kings County for public supply, as both the municipal and private systems have been completely dismantled. The County is now supplied with surface water from upstate sources, and some ground water from wells in Queens and ground-water ponds and wells in Nassau, (see fig. 7A).

In Queens County ground-water pumping by New York City has decreased since 1917, and pumping by two private water companies increased to about 39.9 mgd in 1952. The County is now supplied with surface water from upstate sources, and with ground water from wells in Queens and wells and ponds in Nassau County.

The so-called water shortage of 1949 and 1950 was caused by high consumption and a large deficiency in rainfall in the second half of 1949. In that year the consumption of water from all public-supply sources (both surface and ground water) reached a record high of about 1,167 mgd. In addition, the municipal system supplied about 36.3 mgd to communities outside the city. However, a successful conservation campaign by municipal authorities aimed at reducing consumption for air conditioning, cooling, car washing, and losses due to leaky faucets and mains helped to alleviate the shortage and brought about the appreciable drop in consumption to about 953 mgd in 1950. For comparison it may be pointed out that a minimum of 4 billion gallons per day of salt water is pumped from the tidal channels in New York City by power and industrial plants for use in cooling equipment.

CHEMICAL QUALITY

The general chemical characteristics of the ground water in New York City are shown by the water analyses in table 5. The locations of wells for which complete analyses were obtained are shown in figure 10. No water samples were collected in the field; only readily available records of analyses were used for this report. Some of the records are old and may not represent conditions exactly as they exist at present. The analyses are divided into those representing normal ground water and those showing contamination by sea water. In preparing table 5, a chloride content of 100 ppm was selected arbitrarily as the dividing point between contaminated and uncontaminated water, as a chloride content greater than 100 ppm in this region is considered to be a fairly certain indication of salt-water encroachment, provided there are no other sources of contamination, such as sewage. The analyses were selected to show the considerable range in chemical content of New York City's ground water, according to the geologic formation penetrated and the geographic location of wells. These variations are a function of the interrelation of many complex factors such as type of minerals in the sediments and rocks, dissolving power of the ground water, location of the area with respect to sources of salt-water encroachment (Atlantic Ocean and Hudson and East Rivers), and ground-water levels and pumpage. In some areas of the city the water is not considered potable because the chloride content is too high, or the water may contain concentrations of other constituents which exceed tolerances for certain industrial uses. Because of their importance, some of these constituents, such as chloride, iron, dissolved solids, and hardness, warrant further discussion.

Table 5.—Chemical analyses of water from selected wells in New York City

(Analyses by the New York City Bureau of Water Supply, unless indicated otherwise. Dissolved constituents given in parts per million)

Well number	Depth (feet)	Geologic unit	Date of analysis	Dissolved solids	Iron (Fe)	Nitrate (NO_3)	Bicarbonate (HCO_3)	Chloride (Cl)	Total hardness (as $CaCO_3$)	Total alkalinity (as $CaCO_3$)	pH	Remarks
Wells uncontaminated by sea water												
BRONX COUNTY												
B4	300	Inwood limestone	5-25-39	668	0.1	11	322	60	420	264	..	
B9	140	Manhattan schist	6-12-36	308	.1	1.6	81	20	135	66	..	
B10	600	Inwood limestone	4-27-38	606	.1	7.4	322	32	390	264	..	
B16	125	Manhattan schist	2- 6-40	..	6	0	124	25	210	102	..	
B21	225	Inwood limestone	8-16-37	630	.2	5.6	267	24	365	219	..	
B56[a]	215	do.	5- 9-39	646	.1	7.2	..	33	490	290	..	
KINGS COUNTY												
K176[a]	140	Upper Pleistocene deposits	5-15-39	310	.1	8.8	117	22	190	96	7.4	
K305	77	do.	1942	..	.6	10	102	37	220	84	..	
K328	103	do.	6-14-39	290	.1	6.6	112	23	180	92	..	
K464[b]	494	Lloyd sand member of Raritan formation	7-25-50	88	3	..	41	6	26	34	6.6	
K507	100	Upper Pleistocene deposits	1943	606	.03	15	235	43	391	193	..	
K517	212	Jameco gravel	1944	234	.06	.5	127	39	184	104	..	
K1759	135	Upper Pleistocene deposits	6- 9-50	..	.1	6	266	42	324	218	..	
K1980[c]	50	do.	9-21-50	586	..	.2	..	72	392	325	7.5	Sulphates as SO_4, 120 ppm; SiO_2, 19 ppm; Ca, 26 ppm; Mg, 76 ppm.
K1981[c]	100	do.	7-28-50	286	..	2.4	..	17	162	127	7.8	Sulphates as SO_4, 56; SiO_2, 14 ppm; Ca, 51 ppm; Mg, 11 ppm.
K1982[c]	125	do.	7-26-50	657	..	15	..	51	384	178	7.7	Sulphates as SO_4, 180 ppm; SiO_2, 14 ppm; Ca, 84 ppm; Mg, 36 ppm.
K1986[c]	111	do.	9- 8-50	266	..	1.1	..	12	190	94	8.1	Sulphates as SO_4, 37 ppm; SiO_2, 6.4 ppm, Ca, 38 ppm; Mg, 14 ppm.
NEW YORK COUNTY												
Ny53	37	Upper Pleistocene deposits	10-31-38	358	.1	13	159	31	155	130	..	
Ny57	65	do.	11-27-36	530	.1	13	142	61	240	116	..	
Ny70	75	do.	2-19-42	..	.2	15	261	88	300	214	..	
Ny84	30	do.	2- 2-42	..	.1	10	159	32	245	130	..	
Ny89	35	do.	4-27-37	300	.4	5.6	120	25	130	98	..	
Ny139[a]	310	Inwood limestone	5-17-50	..	.5	..	155	98	213	127	7.4	
QUEENS COUNTY												
Q54	78	Upper Pleistocene deposits	4-18-42	..	.1	..	400	63	560	328	..	
Q111[b]	1016	Lloyd sand member of Raritan formation	7-25-50	77	6	..	11	20	14	9	5.6	
Q303	100	Upper Pleistocene deposits	6-27-50	404	.05	11	122	16	220	100	7.2	
Q311	260	Jameco gravel	6-27-50	125	.4	.2	110	4	90	90	7.9	
Q318	250	Magothy (?) formation	1943	114	.03	.5	66	7	70	54	..	
Q367	90	Upper Pleistocene deposits	11- 4-38	422	.4	.2	249	29	210	204	..	
Q559	214	Jameco gravel	1944	239	.75	.2	120	45	166	98	7.6	
Q564	282	Magothy (?) formation	6-27-50	82	.05	3	11	11	27	9	6.5	
Q569	62	Upper Pleistocene deposits	1942	274	.1	.0	44	28	129	36	..	
Q581[b]	690	Lloyd sand member of Raritan formation	7-25-50	36	.2	..	16	4	12	13	6.1	
Q1264	105	Upper Pleistocene deposits	3-16-50	412	.0	16	219	28	288	180	7.7	
Q1479	123	do.	9- 1-50	..	.1	..	56	12	116	46	..	
Q1719[a]	97	do.	1-18-52	161	.06	1.2	67	8	81	55	6.7	
Q1729[c]	49	do.	8-11-50	387	..	.2	..	59	172	94	7.1	Sulphates as SO_4, 86 ppm; SiO_2, 27 ppm; Ca, 65 ppm; Mg, 20 ppm.
Q1730[c]	259	Jameco gravel (?)	8-11-50	222	..	.2	..	47	94	168	8.1	Sulphates as SO_4, 15 ppm; SiO_2, 16 ppm; Ca, 31 ppm; Mg, 13 ppm.

Table 5.—Chemical analyses of water from selected wells in New York City (Continued)

Well number	Depth (feet)	Geologic unit	Date of analysis	Dissolved solids	Iron (Fe)	Nitrate (NO_3)	Bicarbonate (HCO_3)	Chloride (Cl)	Total hardness (as $CaCO_3$)	Total alkalinity (as $CaCO_3$)	pH	Remarks
						RICHMOND COUNTY						
R7	50	Upper Pleistocene deposits	4- 8-42	..	.15	7	285	24	440	234	..	
R14	22	do.	4- 8-42	..	.8	.1	156	20	270	128	..	
R17	74	do.	4- 7-42	..	.1	2.5	151	14	..	124	..	
R29	93	do.	4- 7-42	..	.1	5	105	20	175	86	..	
R35	53	do.	4-11-42	..	.60	2.8	110	21	150	90	..	
R41	135	Cretaceous deposits	4-11-42	..	.25	.5	81	10	85	66	..	
R54	230	do.	4-11-42	..	5.4	.1	41	2	50	34	..	
R63	77	Upper Pleistocene deposits	1-13-50	285	.0	.2	162	38	204	133	..	Composite well field sample
R64	78	do.	10-19-50	..	.05	3.5	180	11	206	148	8.0	do.
R65	79	do.	1-18-50	242	.1	3.6	122	17	169	100	7.1	do.
R66	96	do.	1-18-50	240	.1	2.8	167	17	251	137	7.3	do.
R69	95	do.	3-21-50	220	.4	.8	85	8	108	70	7.6	do.
R88	50-100	do.	4- 4-50	..	..	3.1	178	70	264	146	..	do.
						Wells contaminated by sea water						
						BRONX COUNTY						
B46	200	Inwood limestone	8-30-50	..	.2	1.2	173	2,400	1,040	142	..	
						KINGS COUNTY						
K272	89	Upper Pleistocene deposits	8-17-42	..	.0	1.8	425	3,400	2,200	348	..	
K356	50	do.	6-12-39	5,530	1.0	.0	315	2,450	1,330	258	..	
K510	120	do.	1-31-46	..	.0	6.4	212	530	837	174	..	
K521	430	Lloyd sand member of Raritan formation	1942	1,130	.86	.2	72	497	373	59	..	
K522	300	Jameco gravel	1942	840	.58	3.2	137	326	484	112	..	
K1985[c]	73	Upper Pleistocene deposits	9-11-50	578	1.0	1.2	..	132	162	59	8.0	Sulphates as SO_4, 78 ppm; SiO_2, 8 ppm; Ca, 53 ppm; Mg, 34 ppm.
						NEW YORK COUNTY						
Ny3	47	Upper Pleistocene deposits	9- 4-25	7,030	.15	1.6	1,010	2,710	1,850	830	..	
Ny21	57	do.	2- 3-42	..	2.70	9	320	233	500	262	..	
Ny23[a]	35	do.	3-23-50	..	.35	..	..	3,360	794	..	7.2	
Ny56[a]	83	do.	6-11-52	16,800	.35	..	..	4,720	330	..	..	
Ny61	70	do.	2- 6-42	..	.8	.1	534	10,150	4,000	438	..	
Ny62	90	do.	2-11-42	..	2.75	7	278	440	290	228	..	
Ny81	30	do.	1-30-39	1,220	37	.8	78	350	260	64	..	
Ny96[a]	30	do.	1-23-50	680	.80	3.2	132	196	258	108	..	
Ny101[a]	51	do.	5- 2-50	710	.30	..	195	270	220	160	8.6	
						QUEENS COUNTY						
Q1374[b]	255	Lloyd sand member of Raritan formation	7-25-50	3,780	30	..	32	1,900	800	26	5.3	
						RICHMOND COUNTY						
R19	180	Sand (Cretaceous or Pleistocene)	5-21-45	..	7.5	.2	378	1,550	761	310	..	

[a] Analysis by private laboratory.
[b] Analysis by New York State Department of Health.
[c] Analysis by New York City Transit Authority.

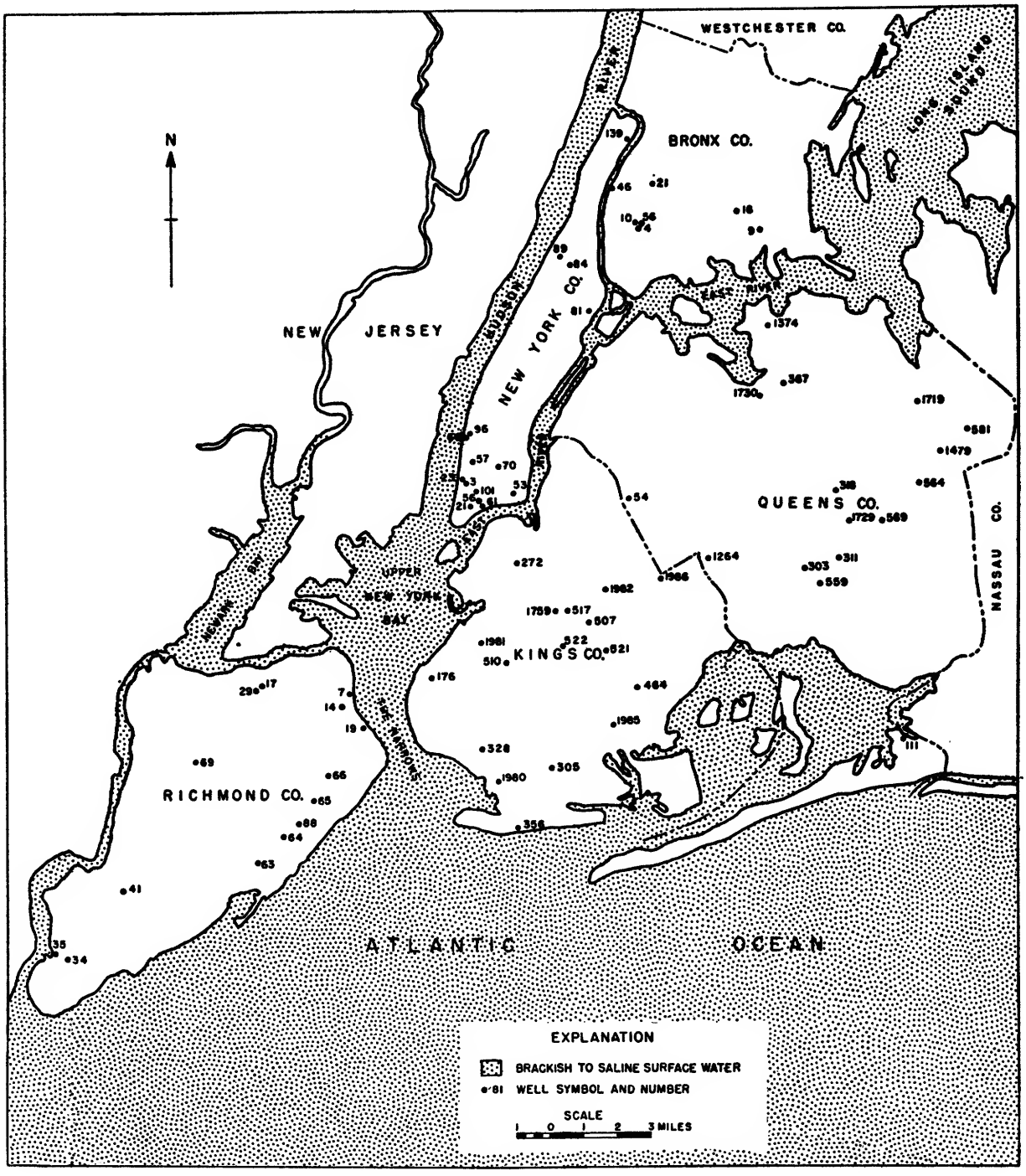

Figure 10.—Location of wells in New York City for which chemical analyses are given in table 5.

According to table 5, none of the aquifers in New York City, unless contaminated by sea water, yields water having a chloride content that is excessive for most industrial uses. The chloride content of uncontaminated water ranges from low values of about 4 ppm in the Magothy (?) formation and Lloyd sand member of the Raritan formation in Queens County to something less than 100 ppm. It is as much as 15,000 ppm in the contaminated upper Pleistocene

deposits of northern and southern Kings County, and is also very high in comparable deposits in southern Manhattan. That the high chloride content in these areas results from encroachment of sea water is substantiated in part by analyses of sea water in New York harbor and several tidal channels in New York City. These show chloride concentrations ranging from about 2,000 ppm to 16,000 ppm (Burr, Hering, and Freeman, 1903, pp. 517-522). The wide range in chloride content is apparently due to tidal and seasonal effects, location of the sampling point, and fresh water discharge of streams flowing into the tidal channels. The normal chloride content of sea water off the coast opposite New York City is about 18,500 ppm. In addition to the chloride concentrations listed in table 5, other figures are given in table 7, for individual wells in Bronx, New York, and Richmond Counties.

The iron content of uncontaminated ground water in both consolidated rocks and unconsolidated sediments in Bronx, New York, and Richmond Counties is generally less than 0.3 ppm, with the exception of water from the Cretaceous deposits in Richmond and some upper Pleistocene deposits which contain water having as much as 6 ppm of iron. In Kings and Queens Counties the iron content varies with the formation, ranging from 0.03 ppm in some upper Pleistocene deposits to 6 ppm in the Lloyd sand member of the Raritan formation. Generally, the iron content exceeds 0.3 ppm in both the Jameco gravel and the Lloyd sand member. Most of the analyses of contaminated ground water in all Counties indicate a high iron content. For example, the iron content in well Q1374 in northern Queens County, a well screened in the Lloyd sand member, is about 30 ppm. It is likely that the high iron is related to the corrosiveness of the saline water.

All the analyses of uncontaminated water listed in table 5 show less than 700 ppm of dissolved solids. The Inwood limestone in Bronx County yields water having the highest content of dissolved solids (average of four analyses is 639 ppm) of all the uncontaminated waters. Water from the Lloyd sand member in Kings and Queens Counties has the lowest content of dissolved solids in the city (average of three analyses is only 67 ppm). Contamination by sea water has increased the content of dissolved solids to at least 18,000 ppm in parts of southern Manhattan and perhaps as much as 25,000 ppm in parts of Brooklyn. Water having more than 1,000 ppm of dissolved solids is likely to contain enough of certain constituents to produce a noticeable taste or otherwise to make the water unsuitable for industrial purposes. However, these waters without treatment are used successfully for purposes such as industrial cooling and air conditioning.

The Inwood limestone yields the hardest uncontaminated water in the city, samples from 5 representative wells averaging about 375 ppm. Water of the lowest hardness in the city (generally less than 50 ppm), occurs in the Magothy (?) formation and Lloyd sand member of the Raritan formation in Queens County and comparable formations in Richmond County. Analyses of 22 water samples from the upper Pleistocene deposits in Richmond, New York, and western Queens Counties show an average hardness of about 250 ppm which is considered somewhat objectionable for many domestic and industrial uses, unless reduced by treatment. As shown in table 5, contamination by sea water materially increases the hardness of ground water in all the aquifers in the city; this is due mainly to the magnesium content of sea water.

TEMPERATURE

In general, the temperature of water used for industrial cooling and air conditioning is more important than its chemical quality, which is fortunate in view of the wide range in chemical content of the ground water described in the foregoing pages, and of the fact that most of the industrial use of ground water is for cooling. Ground-water temperatures are relatively stable throughout the year as contrasted with surface-water temperatures, and where

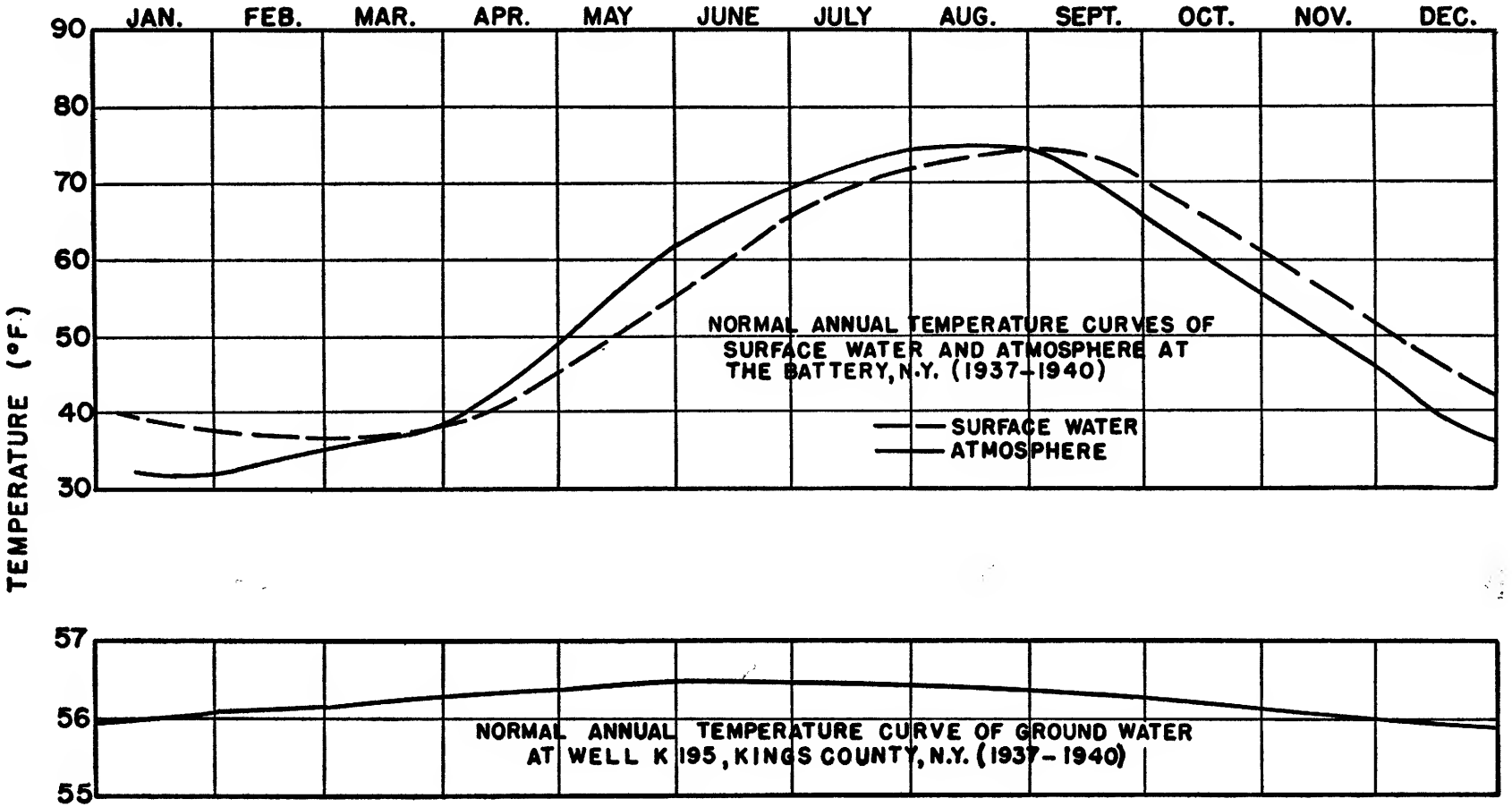

Figure 11.—Annual temperature curves for atmosphere, surface water and ground water, New York City.

it is available in sufficient quantities ground water is usually more economical to use during the cooling season. Figure 11 gives annual temperature curves for the atmosphere and surface water at the Battery in southern Manhattan, and for ground water in an observation well in northern Kings County, all for the years 1937-40. The atmospheric and surface-water curves are based on average monthly readings by the U. S. Weather Bureau and the U. S. Coast and Geodetic Survey, respectively; the ground-water curve is based on average monthly readings by the U. S. Geological Survey. In 1950, the temperature of tap water from the city's Catskill supply at a sampling point in Brooklyn ranged from 36° in March to 66° F. in September and averaged 51° F. for the year, according to readings taken by the Mt. Prospect Laboratory of the Bureau of Water Supply. These readings correspond closely with the temperature curve for surface water shown in figure 11.

The mean annual air temperature in New York City is about 52° F. Where the water table is not too close to land surface, yet is not more than a few hundred feet deep, natural ground-water temperatures are usually within a few degrees of the average annual air temperature. This was substantiated for the Long Island Counties by Brashears (1941, p. 820), who found that the natural ground-water temperature in Kings and Queens Counties ranged from about 52° to 56° F. The few temperature readings collected for this report indicate about the same temperature range for Bronx and Richmond Counties. However, in southern Manhattan substantially higher ground-water temperatures were obtained (averaging about 67° F.) at four wells. The higher temperature may be caused by the many buried steam and sewer pipes which carry fluids having a higher temperature than the ground, the presence of many heated buildings covering the ground, and the induced infiltration of river water, and perhaps in part by the return of warm water to the ground by recharge wells. The latter possibility is probably of minor significance, as there is no evidence of large-scale recharge activities in Manhattan at present. However, in Kings and Queens Counties it was found that the return of warm water (2° to 20° F. higher than normal ground-water temperatures) by recharging wells may cause a gradual rise in average ground-water temperatures (Brashears, 1941, 1946). Nevertheless, except for some parts of northwestern Kings County and a few other isolated places, ground-water temperatures in Brooklyn and Queens have not changed appreciably during the past 10 years in spite of widespread recharging activities.

SUMMARY

Since pre-Revolutionary war days, ground water has played a small but vital role in supplying New York's water-hungry millions. As described in the foregoing pages, ground water is used to a greater or lesser extent in each of the five Counties comprising the city. The amount of ground water consumed in each County varies with the need and availability of such a supply. The latter is dependent, of course, on the geologic and hydrologic conditions which vary greatly throughout the city. These have been summarized for each of the Counties with special emphasis on Bronx, New York, and Richmond.

During times of deficient rainfall, the ground-water supplies have been particularly valuable, being used to augment the public as well as industrial supplies. Thus in 1949, during a period of "water shortage," about 13% of the total consumption of the city was from ground-water sources. Whereas, in 1952, when the city's surface-water supplies were normal, only about 8 percent of the total consumption was from ground-water supplies.

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Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties

Detailed logs of selected wells in Bronx, New York, and Richmond Counties are given in this table. Records for wells in Kings and Queens Counties have been published in other reports. (See references.) The letter and number at the beginning of each well description is the official Water Power and Control Commission designation—for example, B39. The letters and numbers in parentheses, (C-2), are the map coordinates of the wells shown on the well-location maps (pls. 3, 4, and 5). Altitude of land surface is estimated from a topographic map.

BRONX COUNTY

B5; Fanny Farmer Candy Corp., 3825 Corlear Ave. (B-2). Drilled by C. W. Lauman & Co., Inc., 1945. Altitude of land surface about 15 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill, broken rock, clay, and sand	20	20
Sand, coarse, dirty, and rocks	4	24
Sand, fine, and mud	15	39
Sand, coarse, dirty, and gravel	3	42
Sand, gray, and clay	19	61
Clay, sticky, gray	26	87
Sand, dirty, gray, and gravel	6	93
Boulders and black sandy clay	4	97
* Clay, gray	4	101
Clay, sandy, gray, and stones	3	104
Clay, sandy, brown	68	172
Clay, sandy, brown, boulders, and gravel	42	214
Clay, sandy, brown	5	219
Pre-Cambrian (Inwood limestone)		
Rock, hard	13	232
Sandstone, brown	75	307
Sandstone, gray	143	450

Casing: 185 feet of 12-inch
Static water level: 24 feet
Yield: 33 gpm

* The deposits from 97 to 219 feet may include some weathered bedrock but contact is uncertain.

B11; Up-to-Date Candy Manufacturing Co., InC., 1668 Webster Ave. (B-2). Drilled by C. W. Lauman & Co., Inc., January, 1940. Altitude of land surface about 35 feet above sea level. Log begins about 4 feet below land surface. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill	3	3
Boulders, small, with gravel	9	12
Sand, medium, sharp	8	20
Sand and grits	7	27
Gravel, small, and coarse sand	4	31
Sand and gravel, coarse, hard	3	34

(Continued on next page)

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

B11; (Continued)

Sand, brown, coarse	7	41
Clay, sandy, white, hard, no water	6	47
Stones, water bearing	7	54
Pre-Cambrian (Inwood limestone)		
Sandstone, brown	203	257
Clay, white and blue, not hard	3	260
Sandstone, white	19	279
Sandstone, white	86	365
Sandstone, gray, very hard and sharp	22	387

Casing: 54 feet of 10-inch.
Screen: Set from 29 to 39 feet and 49 to 54 feet.
Open hole from 54 to 387 feet.
Pumping test: Duration: 4½ hours
May 12, 1949 Static water level: 10 feet
Drawdown: 75 feet
Yield: 231 gpm

B26; Allied Maintenance Co., Yankee Stadium, East 161 St. (A-1). Drilled by Sweeney & Gray Co., Inc., February, 1950. Altitude of land surface about 20 feet above sea level. Log begins at land surface. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill	30	30
Clay	5	35
Sand, fine, gray	3	38
Sand, coarse, gray	4	42
Sand, fine, brown	5	47
Sand, coarse, brown	18	65
Sand, fine	at	65

Casing: 10 inch.
Screen: 10 feet of 10 inch with bottom at 65 feet.
Static water level: 28 feet below top of casing.
Yield: 300 gpm.

B34; Mayers Restaurant, 612 East 233 St. (B-2). Drilled by Samuel Bargnesian, 1949. Altitude of land surface about 100 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Soil, brown, and boulders	60	60
Pre-Cambrian (Inwood limestone)		
Limestone	570	630

Casing: 6-inch
Screen: None
Static water level: 15 feet (datum unknown)
Yield: 35 gpm

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

B39; Test boring #2, Triborough Bridge Authority, centerline of Bronx-Whitestone Bridge, about 1,650 feet northwest of Old Ferry Point. (A-2). Altitude of land surface about 2 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Mud and meadow mat	2	2
Clay, black, and sand	6	8
Sand, coarse, brown, and boulders	23	31
Sand, brown	10	41
Clay, black, and sand	2	43
Sand, gray	2	45
Sand, brown	8	53
Sand, brown, gravel, and boulders	5	58
Sand, medium, gray	4	62
Sand, coarse, gray	3	65
Pre-Cambrian (Manhattan schist)		
Mica schist, disintegrated	27	92

B53; French-American Reeds Mfg. Co., Inc., 3040 Webster Ave. (B-3). Drilled by C. W. Lauman & Co., Inc., 1947. Altitude of land surface about 70 feet above sea level. Log begins 10 feet below land surface. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Clay, sandy, and boulders	25	25
Gravel, boulders, some clay	20	45
Clay, sandy, yellow	35	80
Sand, medium to coarse, yellow (tested at 10 gpm with 17 ft. drawdown)	12	92
Clay, hard, yellow	15	107
Sand, coarse, grits, and gravel (tested at 3 gpm with 28 ft. drawdown)	12	119
Pre-Cambrian (Inwood limestone)		
Rock, decayed, red	81	200
Clay, tough, yellow	20	220
Rock, decayed, red (water)	20	240
Rock, decayed, yellow (dry)	45	285
Sandstone, soft, brown	25	310
Sandstone, hard, brown	50	360

Casing: 168 ft. of 12-inch with bottom at 148 and 145 feet of 8 inch with bottom at 293.
Static water level: About 8 ft. below street level
Drawdown: 100 ft.
Yield: 70 gpm

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

B54; Meisel's Coats & Dresses, 2910 Third Ave. (A-1). Drilled by C. W. Lauman & Co., Inc., 1952. Altitude of land surface about 20 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Pit	5	5
Fill	7	12
Sand, coarse, brown, and grits	6	18
Sand, medium, brown	7	25
Sand, coarse, brown, and grits	18	43
Sand, medium, brown, and some silty clay	5	48
Sand, coarse, brown, silt, and stones	5	53
Sand, very fine, silty	3	56
Pre-Cambrian (Inwood limestone)		
Rock, decayed	9	65
Sand, fine, brown, silty	4	69
Sandstone	44	113
Sand, fine to medium, gray, and grits	1	114
Sand, very fine, gray (open hole)	19	133

Casing: 69 feet of 8 inch (?)
Pumping test:
Sept. 30, 1952 Duration: 5 hours
Static water level: 29 feet
Drawdown: 90 feet
Yield: 65 gpm

B57; Test boring #2, about 110 feet south of W. 230th Street and 215 feet west of Exterior Street. (B-2). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1941. Altitude of land surface about 2 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill, cinders, sand, and gravel	9	9
Fill, cinders, riprap, sand, clay, and silt	4	13
Peat, soft, with some gray sand	2	15
Peat, soft	9	24
Sand, fine, brown and gray	5	29
Sand, coarse, gray, and gravel	2	31

B59; Hunts Point Sewage Treatment Plant, test boring #101, southwest corner of Ryawa Ave. and Halleck St. (A-2). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1943. Altitude of land surface about 8 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill	9	9
Silt and clay, gray, with shells and some very fine sand	38	47
Sand, loose gravel, and brown silt	6	53
Silt and clay, buff, and wood fragments	5	58
Sand, fine, gray-brown	7	65
Sand, coarse, and gravel	13	78
Pre-Cambrian (Manhattan schist)		
Rock, medium to hard	10	88

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

B65; Police Department Stable, test boring #3, Canal Place and 135th Street. (A-1). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1951. Altitude of land surface about 5 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill, sand, and gravel	10	10
Sand, fine to medium brown, little silt	16	26
Sand, fine to coarse, brown, some gravel, and a little silt	4	30
Pre-Cambrian (Inwood limestone)		
Rock, decomposed	13	43
Limestone, chloritic, fine to medium, gray	6	49

Depth to water 8 feet on 10/22/51.

B69; Hunts Point Sewage Treatment Works, test boring #23, U. S. Bulkhead line on Bronx River, about 1,500 feet west of Patterson and Bronx River Aves. (A-2). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1944. Altitude of land surface about sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Water	6	6
Silt, soft, black	23	29
Silt and fine sand, gray, and shells	28	57
Sand, fine, silty, gray	5	62
Sand, clay, gravel and boulders	9	71
Pre-Cambrian (Manhattan schist)		
Schist	5	76

B70; Unionport Bridge, test boring #60, Brush Ave. and Bruckner Blvd. (A-2). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1945. Altitude of land surface about 13 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill, trace of peat in lower foot	19	19
Silt and clay, gray, with shells	32	51
Sand, fine, gray, and gravel	4	55
Sand, fine, gray	15	70
Sand, fine to coarse, gray, and gravel	4	74
Sand, fine, brown	9	83

NEW YORK COUNTY (MANHATTAN)

Ny23; Greenwich Refrigerating Co., Inc., 402 Greenwich St. (A-1). Drilled by C. W. Lauman & Co., Inc., June, 1937. Altitude of land surface about 10 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill and concrete	3	3
Sand, black	1	4
Clay, blue	5	9
Sand, medium to coarse, and large amount of fine sand	12	21

(Continued on next page)

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Ny23; (Continued)

Sand, coarse, gray, some clay	7	28
Sand, coarse, clean	4	32

Casing: 6 inch to 3 inch.
Screen: 5½ feet of 4 inch with bottom at 35 feet.
Static water level: About 20 feet below land surface.
Yield: 65 gpm.
Chemical analysis: March 23, 1950

pH	7.2
Hardness in parts per million as $CaCo_3$	794
Chlorides as NaC1	3360
Iron as Fe in parts per million	0.4

Ny34; Court Square Building Corp. (Scleifers), 2 Lafayette St. (A-1). Drilled by C. W. Lauman & Co., Inc., May 4, 1938. Altitude of land surface about 25 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill	12	12
Sand, coarse, and grits	11	23
Sand, coarse, and grits, little clay	6	29
Sand, coarse, and grits	26	55
Sand, fine	8	63
Sand, medium, brown	5	68
Sand, coarse and grits	5	73
Sand and gravel, very coarse	22	95

Casing: 8 inch.
Screen: 16 feet of 6 inch with bottom at 87 feet.
Static water level: 13 feet below reference point which is about 16 feet below land surface.
Yield: 190 gallons per minute.

Analysis of water sample by Bureau of Water Supply, City of New York, collected May 9, 1939. (Parts per million)

Chloride	1400	Nitrite	.07
Iron	2.0	Nitrate	16.0
Hardness as $CaCO_3$	660	Alkalinity	236
		Total solids	3290

Ny40; Baker, Williams Warehouse Corp., 98 Morton Street. (A-1). Drilled by Sweeney & Gray Co., Inc. Altitude of land surface about 10 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Hardpan	12	12
Sand and gravel	6	18
Sand, fine	2	20

(Continued on next page)

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Ny40; (Continued)

Sand with clay	18	38
Sand	14	52

Casing: 8 inch.
Screen: 16 feet of 3 inch number 20 slot, Cook strainer.
Static water level: 5½ feet below cellar floor which is about 13 feet below land surface.
Yield: 50 gallons per minute.

Analysis of water sample by Bureau of Water Supply, City of New York, collected February 11, 1942. (Parts per million)

Chloride	140	Nitrite	.02
Iron	3.3	Nitrate	7.0
Hardness as $CaCO_3$	350	Alkalinity	202

Well reported to have dried up July 26, 1944.

Ny41; Downtown Bowling Academy, Inc., 23 Park Row. (A-1). Drilled by C. W. Lauman & Co., Inc., March, 1941. Altitude of land surface about 30 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill	10	10
Sand and stones, coarse, brown	26	36
Sand and grits, some stones, coarse	3	39
Sand and grit, coarse	3	42
Sand, medium, brown, some clay	5	47
Sand, coarse, brown	3	50
Sand, very fine, reddish	5	55
Sand, very fine, dirty, reddish	5	60
Sand, fine, clayey	16	76
Pre-Cambrian		
Rock (Manhattan schist)	at	76

Casing: 8 inch.
Screen: 11 feet of 8 inch with bottom at 55 feet, number 50 slot.
Static water level: 33 feet below top of 8 inch coupling which is about 9½ feet below land surface.
Yield: 158 gallons per minute.
Temperature reported to range from 63° to 64.5° F.

Analysis of water sample by the Bureau of Water Supply, City of New York, collected March 4, 1942. (Parts per million)

Chloride	38	Nitrite	.02
Iron	.20	Nitrate	5.0
Hardness as $CaCo_3$	230	Alkalinity	220

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Ny53; Standard Laundry Service, Inc., 11 Sheriff Street. (A-2). Drilled by C. W. Lauman & Co., Inc., July, 1938. Altitude of land surface about 30 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill	3	3
Sand and gravel, small stones, coarse	4	7
Sand, coarse	4	11
Sand and gravel, coarse	9	20
Sand, medium to coarse	14	34
Sand and gravel, coarse	14	48

Casing: 10 inch.
Screen: 11 feet of 10 inch with bottom at 48 feet.
Static water level: 12 feet below pump base on July 11, 1938.

Ny79; E. Greenbaum Co., 328-30 East 103 Street. (B-2). Drilled in 1940. Altitude of land surface about 10 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Ashes	8	8
Clay, gray, and brown	3	11
Sand and clay, gray	3	14
Bog	1	15
Sand, fine, gray, and mud	5	20
Clay, gray	5	25
Sand and gray clay	3	28
Sand and clay, hard	4	32
Sand, brown, water-bearing	5	37
Clay, gray, and stones	1	38
Clay, red, and red sand	1	39

Casing: 8 inch to 6 inch.
Screen: 6 feet of 6 inch Cook, red brass.
Analysis of water sample by the Bureau of Water Supply, City of New York, collected May 13, 1942. (Parts per million)

Chloride	1600
Iron	9
Nitrate	1.5
Nitrite	.1

Ny105; J. Minders, 111 Barclay Street. (A-1). Drilled by C. W. Lauman & Co., Inc., August, 1943. Altitude of land surface about 5 feet above sea level. Log begins 4 feet below land surface. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill	13	13
Sand, gray, fine to coarse, grits	3	16
Clay, red, solid	3	19
Clay, red, sand and stones	3	22

(Continued on next page)

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Ny105; (Continued)

Clay, sandy, reddish-brown	8	30
Sand, clayey, fine, brown	16	46
Sand, coarse, brown, grits, dirty	12	58
Sand, coarse, brown, uniform, clean	9	67

Casing: 12 inch.
Screen: 16 feet of 8 inch with bottom at 67 feet, number 60 slot.
Static water level: 14 feet below reference point which is about 4 feet below street level.
Yield: 198 gallons per minute.
Drawdown: 15 feet.

Ny108; Libby Baths, Christie and Delancey Streets. (A-2). Drilled by Sweeney & Gray Co., Inc. Altitude of land surface about 45 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Sand	50	50
Sand and clay	10	60
Sand, red	30	90
Clay and sand	50	140
Sand and gravel	10	150
Pre-Cambrian		
Rock	at	150
	(penetrated to 402 feet)	

(Test boring near Ny108)

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Sand, fill	10	10
Sand, coarse	5	15
Sand, coarse and boulders	16	31
Sand, coarse, water-bearing	24	55
Sand, fine	10	65
Clay	7	72
Sand, medium, trace of clay	34	106
Sand and clay	7	113

Ny110; A. Peltz & Son, 220 Greenwich Street. (A-1). Drilled by C. W. Lauman & Co., Inc., April, 1950. Altitude of land surface about 10 feet above sea level. Log begins 4 feet below land surface. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill	4	4
Sand, coarse, brown, and large gravel	7	11
Clay, gray, sandy	2	13
Silt and clay, fine, and trace of gravel	2	15
Clay, red	16	31
Silt, red	16	47
Sand, red, fine to medium	9	56
Silt, red, fine	5	61

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Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Ny110; (Continued)

Casing: 6 inch.
Screen: 11 feet of 6 inch with bottom at 56 feet.
Static water level: 16 feet below basement floor which is about 4 feet below land surface.
Yield: 30 gallons per minute.
Drawdown: 8 feet.
Temperature: 69° F.

Ny111; Windsor Cafeteria, 45 John Street. (A-1). Drilled by C. W. Lauman & Co., Inc., June, 1950. Altitude of land surface about 25 feet above sea level. Log begins 14 feet below land surface. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Concrete, cinders, etc.	2	2
Fill	3	5
Sand and gravel, medium to coarse, red-brown	19	24
Clay, red-brown	29	53
Clay, red-brown, and grits	2	55
Sand, medium to fine, red and clay	2	57
Clay, gray, and grits	1	58
Sand, medium to fine, red, and traces of gravel	8	66
Silt, red	at	66

Casing: 8 inch.
Screen: 10 feet of 8 inch with bottom at 65 feet.
Static water level: 24 feet.
Yield: 70 gallons per minute.

Ny112; The National City Bank, 262 1st Avenue. (A-2). Drilled by C. W. Lauman & Co., Inc., May, 1950. Altitude of land surface about 20 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill and brick	22	22
Sand, fine, brown	11	33
Sand, coarse, brown	3	36
Sand, sharp, light, dead	6	42
Sand, fine, gray, some life	12	44
Sand, very fine, brown and mica, life	9	53
Sand, coarse and brown, mica	2	55
Sand, very fine, brown	26	81
Sand, coarse, brown, and some grits	3	84
Clay, gray	1	85
Gravel	5	90

Casing: 6 inch.
Screen: 5 feet of 6 inch with bottom at 90 feet, slot number 30.
Static water level: 25 feet.
Yield: 40 gallons per minute.
Geologist's log by T. Arnow

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Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Ny112; (Continued)

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill	22	22
Sand, coarse, reddish-brown	10	32
Sand, fine to coarse, reddish-brown	10	42
Sand, medium to coarse, purplish-brown	11	53
Sand, fine, brown, and some clay	28	81
Sand, medium to very coarse, and fine gravel, gray	3	84
Sand, very fine, purplish-gray	1	85
Gravel, fine to coarse, and dark, medium to very coarse sand	1	86
Sand, very coarse, and fine gravel, gray	4	90

Ny114; John Wanamaker, 150 Broadway. (A-1). Drilled by C. W. Lauman & Co., Inc., 1944. Altitude of land surface about 30 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Sand, fine, white	14	14
Clay, brown	3	17
Clay, brown, and sand, some water (22′ to 24′)	7	24
Clay, brown	25	49
Sand, silty, gray, and water	6	55
Clay, light brown	8	63
Clay, brown, and sand	3	66
Sand, very fine, multi-colored, grits, water	7	73
Clay, sandy, fine	1	74
Sand and gravel, coarse	3	77
Pre-Cambrian (Manhattan schist)		
Mica rock	at	77

Casing: 6 inch.
Yield: About 12 gallons per minute.
Static water level: Reported as ranging from 20 to 27 feet below cellar floor or about 40 feet below land surface.
Temperature: 76° F.
Well abandoned May 24, 1944 due to insufficient water. Needed 150 to 200 gallons per minute.

Ny117; New York Savings Bank, 8th Avenue and 14th Street. (A-1). Drilled by C. W. Lauman & Co., Inc., April, 1949. Altitude of land surface about 25 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill	4	4
Boulders, large, sand, coarse	6	10
Sand and stones, coarse	11	21
Sand, fine to medium, trace of gravel	8	29
Sand, fine to medium, lumps of clay	3	32
Clay and grits, brown, sticky	6	38

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Ny117; (Continued)

Pre-Cambrian (Manhattan schist)		
Rock	at	39

Casing: 8 inch.
Screen: 18 feet of 8 inch with bottom at 39 feet.
Static water level: 29 feet.
Yield: 50 gallons per minute.
Well abandoned, supply inadequate.

Ny133; Heermance Storage and Refrigerating Co., 313 Greenwich Street. (A-1). Drilled by Sweeney & Gray, 1941. Altitude of land surface about 15 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleisticene		
Sand, coarse, water-bearing	30	30
Sand, muddy	32	62
Sand, coarse	30	92

Casing: 12 inch to 8 inch.
Screen: 16 feet of 8 inch with bottom at 78 feet, number 32 slot.
Yield: 75 gallons per minute.

Ny138; National Exhibition Club, Polo Grounds. (B-2). Drilled by Artesian Well & Equipment Co., 1950. Altitude of land surface about 20 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill, sand and loam	45	45
Pre-Cambrian (Manhattan schist)		
Rock	312	357

Casing: 45 feet of 6 inch.
Screen: None
Yield: 25 gallons per minute.
Drawdown: 219 feet.

Ny141; Phil Silvershein Corp., 78 Ridge Street. (A-2). Drilled by C. W. Lauman & Co., Inc., 1947. Altitude of land surface about 25 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill	2	2
Sand, very fine, brown, clay and mica	23	25
Clay, brown, sandy	9	34
Clay, brown, solid	8	42
Sand, coarse, brown, gravel, large stones	3	45
Sand, medium, brown, some gravel, stones	5	50
Sand, fine to medium, brown	3	53
Sand, coarse, brown, grits and gravel	7	60
Clay, sandy, gray, and gravel	?	?

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Ny141; (Continued)

Casing: 10 inch.
Screen: 16 feet of 6 inch with bottom at 61 feet.
Static water level: About 15 feet.
Yield: 109 gallons per minute.
Temperature: 57° F.

Ny146; Laundercar System, 555 Grand Street. (A-2). Drilled by C. W. Lauman & Co., Inc., 1950. Altitude of land surface about 40 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Open hole	18	18
Rocks and gravel, mixed	12	30
Sand and gravel, coarse, brown	18	48

Casing: 6 inch.
Screen: 6 feet of 6 inch with bottom at 48 feet, number 40 slot.
Static water level: 18 feet (January 9, 1950).
Yield: 65 gallons per minute.
Temperature: 59° F.

Chemical Analysis, April 5, 1950 (Parts per million).

Chloride	43
Iron	0.2
Hardness (as $CaCO_3$)	79
pH	7.4

Ny154; Cornell Iron Foundry, 25th St. between 10th and 11th Avenues. (A-1). Drilled by Phillips and Worthington. Altitude of land surface about 10 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill	10	10
Sand and gravel	2	12
Sand, fine, brown	3	15
Sand, fine, black	3	18
Mud	6	24
Sand, medium, brown	19	43
Sand, coarse, gravel	4	47
Sand, medium	11	58
Sand, coarse	5	63
Pre-Cambrian		
Rock	at	63

Ny160; East Harlem General Hospital, test boring #62, E. 99th Street, 210 feet east of First Ave. (B-2). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1945. Altitude of land surface about 3 feet above sea level. Driller's log.

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Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Ny160; (Continued)

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill, cinders, and gravel	10	10
Silt, and clay	19	29
Sand, fine, silty, brown	21	50
Sand, fine, silty, brown, and trace of clay	33	83
Silt, red and gray, interbedded with clay, and some fine sand layers	37	120
Sand, fine to coarse gray, and gravel	22	142
Pre-Cambrian (Inwood limestone)		
Limestone, hard	7	149

Ny161; Appellate Division, Court Building, test boring #1, Madison Ave., 50 feet north of E. 25th St. (A-2). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1951. Altitude of land surface about 30 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill, sand, gravel, masonry	5	5
Sand, fine to coarse, brown, with trace of silt and gravel	9	14
Pre-Cambrian (Manhattan schist)		
Rock, hard	9	23

Ny162; Harlem Retail Market, test boring #2, northwest corner of 8th Ave. and W. 142nd St. (B-2). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1950. Altitude of land surface about 20 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill	7	7
Sand, fine to coarse, brown, and trace of gravel	19	26
Sand, fine to medium, brown	11	37
Sand, fine brown, and silt, in layers	17	54
Silt, brown, some layers of clay	22	76
Clay, gray and brown, varved, stiff	24	100
Sand, fine to coarse, brown, and gravel	5	105
Pre-Cambrian (Inwood limestone)		
Limestone, hard, seamy	7	112

Ny163; Inwood Branch Library Building, test #1B, Broadway, about 300 feet north of Dyckman St. (C-2). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1947. Altitude of land surface about 20 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill, sand, clay, and gravel	13	13
Silt, red, stiff	4	17
Sand and gravel, trace of clay and boulders	24	41
Pre-Cambrian (Inwood limestone)		
Limestone, hard	1	42
Clay, rock, stiff decomposed limestone	31	73

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Ny164; Nightingale Hospital, test boring #8, about 70 feet west of Fort Washington Ave. and 200 feet north of W. 163rd Street. (C-2). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1941. Altitude of land surface about 140 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Sand, fine, brown	13	13
Sand and silt, very fine, gray and yellow	3	16
Sand, gravel, clay, and boulders	10	26
Pre-Cambrian (Manhattan schist)		
Rock, seamy and weathered, quality improves with depth	22	48

Ny165; Broadway Bridge, test boring #SA4, east side of Broadway at Harlem River. (C-3). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1951. Altitude of land surface about 5 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill	8	8
Silt, black, with peat	4	12
Sand, fine, brown, and layers of silt	13	25
Silt, red and brown, with some thin streaks of gray clay	22	47
Sand, coarse, and gravel	4	51
Pre-Cambrian (Inwood limestone)		
Limestone, decomposed, yellow-white	2	53
Limestone, fine to coarse, gray	6	59

RICHMOND COUNTY

R7; New Method Service Co., Inc., 465 Bay Street. (C-4). Drilled by C. W. Lauman & Co., Inc., February, 1941. Altitude of land surface about 10 feet above sea level. Drillers log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill	4	4
Clay and sand, gray	19	23
Clay, brown	4	27
Sand and gravel, coarse, and brown clay	11	38
Sand and gravel, clean, coarse	12	50

Casing: 10 inch.
Screen: 11 feet of 8 inch with bottom at 50 feet.
Yield: 200 gallons per minute.
Temperature: 57° F.

R10; Clay Smith Co., Inc., 789 Henderson Avenue. (C-3). Drilled by C. W. Lauman & Co., Inc., January, 1938. Altitude of land surface about 18 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill	1	1

(Continued on next page)

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

R10; (Continued)

Clay	29	30
Clay and boulders	7	37
Clay	2	39
Sand and clay	26	65
Sand and gravel	14	79
Sand, clean	8	87

Casing: 8 inch.
Screen: 13 feet of 6 inch with bottom at 87 feet.
Yield: 270 gallons per minute.
Drawdown 9 feet.

R14; Park Lanes, Inc., 164-70 Canal Street. (C-4). Drilled by C. W. Lauman & Co., Inc., 1941. Altitude of land surface about 30 feet above sea level. Log starts 5 feet below land surface. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill	2	2
Sand, coarse, small gravel, red clay	4	6
Sand, coarse, brown, broken stones, some water	23	29
Sand, coarse, brown, grits, small gravel	9	38
Same as above with clay	5	43

Casing: 6 inch.
Screen: 6 feet of 6 inch with bottom at 42 feet.
Static water level: 7 feet below top of casing.
Yield: 40 gallons per minute.
Temperature: 57° F.

R17; Blue White Laundry, Inc., 685 Cary Avenue. (C-3). Drilled by C. W. Lauman & Co., Inc., August, 1939. Altitude of land surface about 30 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Clay, sand and stones	9	9
Clay, sand, stones and rocks	55	14
Clay, gray	14	28
Clay, some grits	6	34
Clay, boulders	5	39
Sand, coarse, some clay	4	43
Gravel, little clay	4	47
Sand, medium to coarse	6	53
Sand and grits	3	56
Sand and gravel, clean, coarse	19	75

Casing: 8 inch.
Screen: 16 foot of 6 inch with bottom at 74 feet.
Static water level: 29 feet.
Yield: 350 gallons per minute.
Temperature: 54° F.

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

R18; Ansbacher Siegle Corp., 92 Chestnut Street. (C-4). Drilled by C. W. Lauman & Co., Inc., March, 1937. Altitude of land surface about 45 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Loam, hard, red, niggerheads, and boulders	46	46
Clay, hard, red, 10% fine sand	11	57
Clay, hard, red, and niggerheads	3	60
Clay, hard, red, large stones, and niggerheads	10	70
Sand, fine, large stones, 10% small gravel and 40% red clay	7	77
Sand, medium to coarse, brown, small gravel and 10% red clay	11	88
Same as above with large stones	4	92
Sand, clean, coarse, heavy gravel, large stones	9	101
Sand, clean, coarse, brown, heavy gravel	17	118
Sand, coarse, brown, small gravel, some red clay	5	123
Sand, clean, coarse, greenish	8	131
Sand, medium to coarse, clean, brown	8	139
Sand, fine, brown	3	142

Casing: 12 inch.
Screen: 31 feet of 11 inch with bottom at 139 feet.
Static water level: 47 feet.
Yield: 370 gallons per minute.

R42; People's Pulpit Association, Radio Station WBBR, 1111 Woodrow Road. (B-2). Drilled by H. L. Parkhurst, April, 1931. Altitude of land surface about 150 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Clay	29	29
Clay, sand and gravel	11	40
Sand, coarse and gravel	16	56
Sand, gravel and clay, no water	30	86
Sand, yellow	4	90
Cretaceous (Raritan formation)		
Sand, gray and clay mixed	34	124
Sand, gray, water struck at 124 feet and lost at 136 feet	12	136
Sand and clay	2	138
Clay	7	145
Clay, blue	3	148
Sand, medium, gray, and clay, mixed	10	158
Clay and fine sand, water struck at 158 feet and lost at 166 feet	12	170
Sand, fine and white clay	11	181
Sand, fine and gray clay	6	187
Clay, blue	18	205
Clay, blue and gray mixed	45	250
Clay, blue, heavy	32	282
Clay	16	298
Clay and sand	5	303

(Continued on next page)

R42; (Continued)

Pre-Cambrian		
Mica schist	at	360

Two wells in Cretaceous strata 135 feet and 165 feet deep, reported on this property. The log given above may be for a test well at this site. See tables 5 and 6 for additional data.

Casing: 8 inches.

R54; Beinerts Ice Co., Inc., 50 Murray Street. (B-2). Drilled by Artesian Well & Equipment Co., Inc., June, 1936. Altitude of land surface about 20 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Clay	26	26
Sand	1	27
Sand and clay	16	43
Clay, light	4	47
Sand and gravel	8	55
Cretaceous (Raritan formation)		
Clay, gray	35	90
Clay	87	177
Sand	5	182
Sand	46	228

Casing: 6 inch.
Screen: 20 feet of 6 inch with bottom at 228 feet.
Static water level: 37 feet (June, 1936)
Drawdown: 53 feet.
Yield: 200 gallons per minute.
Specific capacity: 4

R55; Board of Transportation, City of New York, Castleton Avenue and Rector Street. (C-3). Drilled by C. W. Lauman & Co., Inc., August, 1950. Altitude of land surface about 18 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill	15	15
Clay, red and stones	10	25
Clay, light, red	11	36
Sand, reddish-brown, and some clay	9	45
Sand, brown, and stones	36	81

Casing: 12 inch.
Screen: 21 feet of 12 inch with bottom at 81 feet.
Static water level: 5 feet (August, 1950).
Yield: 310 gallons per minute.
Drawdown: 9 feet.
Specific capacity: 34

(Continued on next page)

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

R55; (Continued)

Geologist's log based on examination of samples by T. Arnow.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
No sample	15	15
Clay and silt, brown, and fine to coarse sand	10	25
Clay, silt, brown, and fine gravel	11	36
Sand, medium to very coarse, brown, and fine gravel	9	45
Sand, medium to very coarse, brown, and fine to medium gravel	36	81

R56; Test boring #1, Oakwood Beach. (B-3). Drilled by the Subsurface Exploration Section, Department of Public Works, City of New York, 1949. Altitude of land surface about 2 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand, fine to medium, dark red, trace of silt, a little fine to coarse gravel	8	10
Sand, fine to medium, compact, traces of silt, and fine gravel	20	30
Sand, fine to coarse, brown, trace of silt, and fine to medium gravel	24	54
Cretaceous (Raritan formation)		
Silt and clay, light gray, compact, in layers, some layers of pink clay	9	63
Sand, fine to medium, yellow and gray, silt, compact, some layers of pink clay	7	70
Sand and silt, fine, light gray, compact in alternating layers, some layers of pink clay	26	96
Sand, fine to medium, multi-colored, in layers, trace of silt and clay	6	102

Correlation based on examination of samples by N. M. Perlmutter.

R57; Richmond Health Substation, test boring, Center Street, about 60 feet west of St. Patrick's Place. (B-3). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1941. Altitude of land surface about 30 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Sand and gravel, red, with silt and clay	16	16
Sand, fine to medium, brown, some silt	12	28
Sand and gravel, red, compact, some silt and clay	32	60
Sand and gravel, red, compact	12	72
Cretaceous (Raritan formation)		
Clay, stiff, dark gray, some silt and carbonized wood	54	126
Pre-Cambrian		
Gneiss, decomposed	55	181

R58; Seaview Hospital, Rockland and Brielle Avenues. (C-3). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1950. Altitude of land surface about 295 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Sand, fine to coarse, reddish-brown, pebble to medium gravel, some clay	27	27
Gravel, pebble to large, red shale, some stiff clay, and fine to coarse sand	10	37
Sand, fine to medium, red, pebble gravel, some red clay	3	40
Pre-Cambrian (Staten Island serpentine of Merrill)		
Serpentine, soft, weathered, green and speckled	7	47

R59; Test boring #1PS, 280 feet west of Bodine Street and 600 feet north of Richmond Terrace. (C-3). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York, 1944. Altitude of land surface about 2 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill	12	12
Silt, soft	16	28
Silt, fine, gray and sand, trace of gravel and peat	9	37
Silt, clay, and fine sand, loose	6	43
Sand, fine, brown, compact	9	52
Sand, clay, and gravel, compact	13	65
Sand, fine to medium, brown, compact	30	95
Sand, coarse, gravel and boulders	7	102
Sand, fine, compact	3	105

R60; Marine Unloading Plant, test boring #2A, East shore of Great Fresh Kills Creek. (B-2). Drilled by Subsurface Exploration, Department of Public Works, City of New York, 1946. Altitude of land surface about 1 foot above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Sand, fine to medium, brown	11	11
Silt and clay, stiff, red, and gravel	5	16
Sand and gravel, red, poorly sorted, trace of clay	16	32
Sand, medium to coarse, compact, some dark gray silt	3	35
Cretaceous (Raritan formation)		
Silt, stiff, dark gray, some clay, fine sand, fragments of carbonized wood	6	41
Sand, coarse, white	2	43
Clay, stiff, blue-green, silt and sand	5	48
Triassic (Newark group)		
shale, gray, very stiff	5	53
Pre-Cambrian		
Rock decomposed, serpentine	23	76

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

R61; Atlantic Terracotta Co., Tottenville. (B-2). Drilled by W. Stothoff Co., Inc. Altitude of land surface about 5 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Clay, red, and gravel	2	2
Sand, brown	1	3
Sand, yellow	27	30
Clay and gravel	30	60
Sand, brown, water	3	63
Sand, coarse, and clay	6	69
Sand, light brown, water	3	72
Sand, coarse, and clay	1	73
Cretaceous (Raritan formation)		
Clay, light	5	78
Clay, blue and sand	38	116
Sand, fine, light	1	117
Clay, pink	11	128
Clay, black	2	130
Sand, light, water	4	134
Sand, light, and clay mixed	13	147
Sand, light, water	4	151
Sand, coarse, white, water	3	154
Sand, light	9	163

Casing: 6 inch.
Yield: Reported to vary from 50 to 140 gallons per minute.

R62; Great Kills Library, test boring #1, Margaret Street, 110 feet west of Giffords Lane. (B-3). Drilled by Subsurface Exploration Section, Department of Public Works, City of New York. Altitude of land surface about 65 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Loam, sand and gravel	12	12
Sand, clay and gravel	5	17
Sand and gravel, reddish-brown, trace of clay	34	51

R63; Boulevard Station #1, Well No. 7, Department of Water Supply, Gas and Electricity, City of New York, Emmett Avenue and Hylan Boulevard. (B-3). Drilled by Phoenix Construction Co., 1912. Altitude of land surface about 10 feet above sea level. Driller's log.

Recent and Pleistocene

	Thickness (feet)	Depth (feet)
Topsoil	5	5
Clay, sand, gravel and boulders	3	8
Sand, red	12	20
Sand, fine, brown	6	26
Sand, coarse, brown	7	33
Sand, fine	6	39

(Continued on next page)

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

R63; (Continued)

Sand, coarse, and gravel	11	50
Sand, coarse, brown, and gravel	5	55
Clay, white	1	56
Sand, beach, and some gravel	3	59
Sand, beach, light brown	3	62
Sand, beach, light brown	3	65
Sand, coarse, brown	7	72
Sand, coarse, brown, and gravel	3	75
Cretaceous (Raritan formation)		
Clay, white, and gravel	2	77
Clay, white	23	100
Sand, beach, light brown	10	110
Clay, blue	11	121
Clay, white	1	122
Clay, blue	27	149
Clay, blue and hardpan	2	151
Clay, blue	41	192
Clay, gray, trace of hardpan	14	206
Clay, gray	4	210
Clay, red, blue and gray in streaks	4	214
Clay, gray, trace of hardpan	4	218
Clay, dark red, mixed with gray clay	11	229
Clay, light red, mixed with sand	9	238
Clay, red, blue and gray	4	242
Sand, beach, white	4	246
Clay, gray, traces of lignite	4	250
Clay, blue, red and gray, some mica	20	270
Pre-Cambrian		
Bedrock, soapstone with mica	49	319

Casing: 6 inch.
Screen: 6 inch diameter set from 45 to 55 feet and 65 to 75 feet.
Yield: 120 gallons per minute.
One of 14 wells discharging into a common suction line.

R64; Boulevard Station #2, Well No. 9, Department of Water Supply, Gas and Electricity, City of New York, Hylan Boulevard, about 450 feet south of New Dorp Lane. (B-3). Drilled by Phoenix Construction Co., 1912. Altitude of land surface about 10 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Sand, and loam	12	12
Sand, fine, and clay	9	21
Sand, fine, brown	13	34
Sand, coarse, brown, and gravel	17	51

(Continued on next page)

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

R64; (Continued)

Gravel, fine	12	63
Gravel	15	78
Cretaceous (Raritan formation)		
Clay, white	17	95
Sand, very fine, yellow	6	101
Clay, white	2	103
Sand, very fine, white	2	105
Sand, very fine, gray, mica	6	111
Clay, blue	23	134
Sand, fine, brown, traces of mica	1	135

Casing: 6 inch.
Screen: 23 feet of 6 inch with bottom at 72 feet.
One of 14 wells discharging into a common suction line.

R65; Boulevard Station #3, well No. 12, Department of Water Supply, Gas and Electricity, City of New York, Hylan Boulevard and Buel Avenue. (C-3). Altitude of land surface about 10 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Loam and sand	11	11
Sand, fine, red	22	32
Sand, coarse, and gravel	11	43
Sand, fine, gray	1	44
Clay, blue	10	54
Gravel, fine to coarse	31	85
Cretaceous (Raritan formation)		
Clay, blue and white	2	87

Casing: 6 inch
Screen: 12 feet of 6 inch with bottom at 44 and 12 feet of 6 inch with bottom at 79.
Yield: 126 gallons per minute.

R66; Boulevard Station #4, well No. 9, Department of Water Supply, Gas and Electricity, City of New York, Hylan and Evergreen Avenue. (C-3). Drilled by Phoenix Construction Company, 1912. Altitude of land surface about 12 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Sand, coarse, brown	18	18
Quicksand	12	30
Sand, fine, brown	24	54
Sand, coarse brown	3	57
Gravel	1	58
Sand, coarse, white	9	67
Clay, gray	3	70
Gravel, coarse	18	88

(Continued on next page)

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

R66; (Continued)

Gravel	3	91
Gravel, fine	5	96
Cretaceous (Raritan formation)		
Clay	3	99

Casing: 6 inch.
Screen: 12 feet of 6 inch with bottom at 67 feet and 24 feet of 6 inch with bottom at 96 feet.
Yield: 700 gallons per minute.

R67; Test boring, Goethals Bridge, Port of New York Authority, 170 feet east of Arthur Kill & Goethals Bridge, 1927. (C-2). Altitude of land surface about 3 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Soil	1	1
Silt	27	28
Sand	4	32
Gravel	6	38
Triassic (Newark group)		
shale, red	13	51

R68; Test boring, Bayonne Bridge, Port of New York Authority, Newark Avenue and Innis Street, 1929. (C-3). Altitude of land surface about 35 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Topsoil and red clay	6	6
Clay, stiff, red	5	11
Clay, hard, red, very little sand and gravel	9	20
Sand, gravel and boulders	14	34
Triassic (Palisade diabase)		
Trap rock	9	43

R69; Bulls Head Pumping Station, Department of Water Supply, Gas and Electricity, City of New York. (C-3). Altitude of land surface about 20 feet above sea level. Driller's log, supplied by M. E. Johnson.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Bog, black, some sand	8	8
Clay, red and yellow	19	27
Hardpan, gray	3	30
Sand, fine, brown, water bearing	10	40
Sand, coarse, brown, water bearing	25	65
Clay, red	5	70
Sand, coarse, brown, some gravel	15	85
Clay, red	2	87
Sand, dark, coarse, some gravel	8	95

R70; Nassau Smelting and Refining Co., Inc., 1 Nassau Place. (B-2). Drilled by Artesian Well & Equipment Co., 1948. Altitude of land surface about 15 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Fill	18	18
Hardpan, sand and a little red clay	55	73
Sand and gravel, water bearing	11	84
Cretaceous (Raritan formation)		
Clay, gray, and a little red clay	76	160
Clay, gray, with a little sand	37	197
Clay, gray	20	217
Clay, red	58	275
Hardpan, sand and clay, mixed	26	301
Clay, hard, pieces of red sandstone	7	308
Clay, hard	45	353
Bedrock (Age?)	at	353

Well abandoned.

R71; Test boring, Raritan Bay Bridge, about 1 mile north of Seguine Point at Prince's Bay. (B-2). Altitude about 30 feet above sea level. Driller's log supplied by M. E. Johnson.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Sand	16	16
Sand, coarse, and gravel	15	31
Mud	25	56
Sand, coarse and gravel	14	70
Cretaceous (Raritan formation)		
Mud	50	120
Sand, fine	1	121
Hardpan and gravel	3	124
Sand, fine, white	23	147

R72; Harry Chassey, near ferry slip at Tottenville. (B-1). Drilled about 1911. Altitude of land surface about 20 feet above sea level. Driller's log supplied by M. E. Johnson.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Clay, red, hard	20	20
Clay, softer, some fine sand	40	60
Gravel, coarse	10	70
Cretaceous (Raritan formation)		
Clay, hard	80	150
Sand, coarse, water bearing	23	173

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

R73; Rubsam and Horrmann Brewery, test well, 191 Canal Street. (C-4). Drilled by S. J. Breen, 1946. Altitude of land surface about 50 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Fill	10	10
Clay	26	36
Sand, stones, some clay	4	40
Clay, brown	3	43
Stones, sand, and clay	20	63
Clay, green	17	80
Pre-Cambrian		
Serpentine	at	80

Casing: 8 inch.
Screen: 10 feet with bottom at 58 feet.
Yield: 10 gallons per minute.

R74; Test well, Department of Water Supply, Gas and Electricity, City of New York, Cortlandt Street and Haughwout Avenue. (C-3). Altitude of land surface about 20 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Clay, red, and gravel	2	2
Clay, red, and loam	2	4
Clay, red, sand, and gravel	2	6
Gravel, sand, clay and boulders	9	15
Serpentine (?) and sand	3	18
Gravel	2	20
Sand, fine, and gravel	3	23
Sand, fine, and boulders	3	26
Clay, stiff	2	28
Sand, fine, and clay	3	31
Sand, red	1	32
Sand and gravel	5	37
Sand, brown	2	39
Sand, brown, and gravel	12	51
Gravel, coarse	4	55
Sand and coarse gravel	5	60
Gravel, very coarse	10	70
Sand and gravel, heavy	5	75
Sand and coarse gravel	5	80

R75; Test boring, City of New York, Narrows Tunnel Project, Forest Avenue, 300 feet east of Clove Road. (C-3). Drilled in 1922. Altitude of land surface about 85 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Clay, red, fine, sand, and gravel	25	25

(Continued on next page)

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

R75; (Continued)

Clay, red and gray, gravel, pebbles and sand	24	49
Boulders, granite	1	50
Sand, coarse, and gravel	19	69
Pre-Cambrian		
Serpentine, decomposed	6	75
Serpentine, hard	10	85

R76; Test boring, City of New York, Narrows Tunnel Project, Broadway and Forest Avenue. (C-3). Drilled in 1922. Altitude of land surface about 115 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Clay, red, sand and large gravel (till)	11	11
Clay, red, sand, and small gravel, water-bearing	16	27
Clay, red, and gravel	13	40
Clay, red, red and green pebbles	13	53
Sand and red clay, water-bearing	14	67
Pre-Cambrian		
Serpentine (bedrock)	22	89

R77; Test boring, City of New York, Narrows Tunnel Project, Bement Avenue, about 390 feet north of Forest Avenue. (C-3). Drilled in 1922. Altitude of land surface about 120 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Clay, sand and gravel (till)	16	16
Pre-Cambrian		
Serpentine (bedrock)	at	16

R78; Test boring, City of New York, Narrows Tunnel Project, Forest and Davis Avenues. (C-3). Drilled in 1922. Altitude of land surface about 130 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Clay, yellow, and sand	19	19
Clay, red, sand and gravel	10	29
Sand, coarse, and a little red clay	17	46
Sand, fine, red, and red clay	13	59
Sand	8	67
Sand and gravel	9	76
Sand, fine, red	12	88
Clay, red	3	91
Pre-Cambrian		
Serpentine (bedrock)	at	91

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

R79; Test boring, City of New York, Narrows Tunnel Project, Van Tuyl and York Avenues. (C-3). Drilled in 1922. Altitude of land surface about 120 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Loam	4	4
Shale, soft, red	6	10
Pre-Cambrian		
Serpentine (bedrock)	34	44

R80; Test boring, City of New York, Narrows Tunnel Project, St. Mark's Place and Hyatt Street. (C-4). Drilled in 1922. Altitude of land surface about 110 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Loam	4	4
Pre-Cambrian		
Serpentine, weathered (bedrock)	11	15
Serpentine	22	37

R81; Test boring, City of New York, Narrows Tunnel Project, Borough Place and Bay Street. (C-4). Drilled in 1922. Altitude of land surface about 40 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent and Pleistocene		
Loam, sand, clay, stones	10	10
Clay, red, gray sand, stones, and gravel	24	34
Pre-Cambrian		
Serpentine (bedrock)	15	49

R82; Quarantine Station, Hoffman Island, Lower New York Bay. (B-4). Reprinted from U. S. G. S. Prof. Paper 44. Drilled by E. Gregory. Altitude of land surface about 5 feet above sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Recent, Pleistocene and Cretaceous (?)		
Sand, clay and gravel with salt water	450	450
Pre-Cambrian		
Rock with salt water	300	750
Rock with fresh water	250	1000

Sample at 210 feet reported by A. C. Veatch to be a dark blue-gray sand, apparently glacial.

Casing: 8 inch.
Yield: 33 gallons per minute.

Table 6.—Logs of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

R83; Test boring, Goethals Bridge, Port of New York Authority, about 800 feet west of Western Avenue, 30 feet south of Washington Avenue. (C-2). Altitude of land surface about 3 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Silt	15	15
Sand, coarse, red	16	31
Sand, fine, red	17	48

R89; Test boring #3, Narrows Project, New York City Transit Authority, Bay Street, Ormond Place and Butler Place. (C-4). Drilled by the Giles Drilling Corp., 1931. Altitude of land surface about 25 feet above sea level. Driller's log.

Recent and Pleistocene (?)	Thickness (feet)	Depth (feet)
Sand and gravel	14	14
Sand, clay, and gravel	21	35
Clay and gravel	1	36

R91; Test boring #4, Narrows Project, New York City Transit Authority, Clifton Avenue and Rosebank Place. (C-4). Drilled by the Giles Drilling Corp., 1931. Altitude of land surface about 25 feet above sea level. Driller's log.

Recent and Pleistocene (?)	Thickness (feet)	Depth (feet)
Clay and gravel	12	12
Sand and clay	8	20
Sand, clay, and gravel	20	40

R93; Test boring #6, Narrows Project, New York City Transit Authority, Maryland Avenue and White Street. (C-4). Drilled by the Giles Drilling Corp., 1931. Altitude of land surface about 25 feet above sea level. Driller's log.

Recent and Pleistocene (?)	Thickness (feet)	Depth (feet)
Clay	19	19
Mud	3	22
Clay and gravel	30	52

R94; Test boring #8, Narrows Project, New York City Transit Authority, St. John Avenue and White Street. (C-4). Drilled by the Giles Drilling Corp., 1931. Altitude of land surface about 25 feet above sea level. Driller's log.

Recent and Pleistocene (?)	Thickness (feet)	Depth (feet)
Mud	38	38
Clay and gravel	18	56
Sand, clay, and gravel	3	59

R95; Test boring #9, Narrows Project, New York City Transit Authority, Hope Avenue, about 220 feet west of Bay Street. (C-4). Drilled by the Giles Drilling Corp., 1931. Altitude of land surface about 35 feet above sea level. Driller's log.

Recent and Pleistocene (?)	Thickness (feet)	Depth (feet)
Mud and clay	36	36
Clay and gravel	32	68

R98; Test boring #1, Narrows Project, New York City Transit Authority, Wadsworth Road and Seagate Road. (C-4). Drilled by the Giles Drilling Corp., 1931. Altitude of land surface about 55 feet above sea level. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Clay, sand, and gravel	15	15
Clay, gravel, and boulders	128	143

R99; Test boring #NR 18, Narrows Project, New York City Transit Authority, in Hudson River, about 150 feet east of shore near Seagate Road. (C-4). Drilled by the Giles Drilling Corp., 1931. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Water	16	16
Gravel and boulders	10	26
Sand, coarse, and gravel	7	33
Sand and gravel	14	47
Sand, fine	13	60
Sand and gravel	26	86
Sand	25	111
Sand and gravel	3	114

R100; Test boring #NR 12, Narrows Project, New York City Transit Authority, in Hudson River, about 1,800 feet from shore near Seagate Road. (C-4). Drilled by the Giles Drilling Corp., 1931. Driller's log.

Recent and Pleistocene	Thickness (feet)	Depth (feet)
Water	90	90
Silt and sand	8	98
Sand, fine	9	107
Sand and shells	15	122

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties

Location: From records, not checked in the field.
Map coordinates: Consist of a letter and number identifying the 5-minute grid square in which the well is located in plates 3, 4 and 5.
Owner: From original records. In the case of old wells, ownership may have been changed.
Altitude: Approximate elevation of land surface above mean sea level. Estimated from a topographic map.

Type of well: Drl, drilled; Drv, driven.
Method of lift: A, air-lift; E, electric; J, jet; R, reciprocating; S, suction; St, steam; T, turbine. Source of power is electricity unless indicated otherwise.
Use: AC, air conditioning; C cooling or condensing; D, domestic; F, flushing or washing; I, irrigation; L, laundry; P, processing; PS, public supply; S, swimming pool.

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
						BRONX COUNTY								
B1	3974 Boston Rd.	B-3	Holler Ice Manufacturing Co., Inc.	20	Drl	600	12	Manhattan schist	T	200	200	C	60 11- 7-44	Depth to bedrock, 20 feet. Well operated from June to September.
B2	625 Brook Ave.	A-2	Swift & Co., Inc.	15	Dug	12	10	Pleistocene sand	S	150	..	..	..	Well not used, has been dry. Near B3.
B3	643 Brook Ave.	A-2	Ridgefield Refrigeration Service, Inc.	15	Drl	55	10	do.	T	300	250	C	125 6-24-41	B2, nearby. Screen set from 43 to 55 feet.
B4	979 Brook Ave.	A-2	The Borden Co.	15	Drl	300	8	Inwood limestone	T	350	300	C	51 7-30-42	Depth to bedrock, probably 120 feet. For chemical analysis see table 5. Static level about 26 feet.
B5	3825 Corlear Ave.	B-2	Fanny Farmer Candy Corp.	15	Drl	450	12-6	do.	T	100	70	C	370 7- 9-48	Depth to bedrock, uncertain. For log see table 6.
B6	281 E. 132d St.	A-1	Arctic Hygeia Ice Co.	10	Drl	36	8	Pleistocene sand ?	..	..	150	C	..	Well not in use. Two other wells on property also abandoned.
B9	2338 Hermany Ave.	A-2	Karsten Dairies, Inc. (Hermany Farms)	15	Drl	140	6	Manhattan schist	T	50	50	C	40 7-11-41	Depth to bedrock, unknown. For Chemical analysis see table 5.
B10	1045 Webster Ave.	A-2	Sheffield Farms Co., Inc.	15	Drl	600	6	Inwood limestone	T	..	110	C	29 7-11-41	Depth to bedrock, 145 feet. For Chemical analysis see table 5.
B11	1668 Webster Ave.	B-2	Up-to-Date Candy Manufacturing Co., Inc.	35	Drl	387	10 and 8	Pleistocene sand and Inwood limestone	T	250	230	C	35 7- 6-42	Temperature of water, 57° F. For log see table 6. Screen set from 29 to 39 feet and 39 to 49 feet.
B12	520 Westchester Ave.	A-2	Bronx Refrigeration Co., Inc.	15	Drl	222	8	do.	T	200	65	C	185 7-11-41	Depth to bedrock, probably 130 feet. Three other wells, nearby.
B16	2128 Westchester Ave.	B-2	Atlantic Asbestos Corp.	30	Drl	125	8	Manhattan schist	R	60	60	C	23 7-11-41	Depth to bedrock, probably 10 feet. Iron content, 5 parts per million on 7-11-41.
B17	1160 Worthen St.	A-2	Frank Tursellino & Co., Inc.	15	Drl	230	8	do.	T	60	60	C	..	Depth to bedrock, unknown.
B19	431 E. 165th St.	A-2	Coca-Cola Bottling Co. of N. Y., Inc.	20	Drl	1800	9	Inwood limestone	T	250	150	C	..	Pumping level, 278 feet. Well abandoned. B20, nearby.
B20	do.	A-2	do.	20	Drl	800	8	do.	T	250	150	C	..	Pumping level, 290 feet. Well abandoned.
B21	421 E. 174th St.	B-2	Manchester Cream Co., Inc.	35	Drl	225	8	do.	T	150	50	C	29 6- 5-42	Depth to bedrock, 25 feet. For chemical analysis see table 5.
B26	Yankee Stadium	A-1	Allied Maintenance Co.	20	Drl	65	10	Pleistocene sand	J	300	125	I,C	50 9-29-50	Intermittent seasonal operation. Drawdown reported to be 15 feet after pumping 8 hours at 125 gallons per minute. For log see table 6.

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
B28	Locust Ave. and 134th St.	A-2	Great Atlantic & Pacific Tea Co.	15	Drl	250	6	Inwood limestone	T	..	30	C	..	Well not in use. Depth to bedrock, probably 30 feet. Drawdown reported to be 75 feet after pumping 8 hours at 30 gallons per minute.
B29	1400 Ferris Pl.	B-2	F. M. Schildwachter & Sons, Inc.	15	Drl	70	12	Pleistocene sand	..	..	400	C	..	Well not in use. Drawdown reported to be 58 feet after pumping 12 hours at 400 gallons per minute.
B32	1150 Webster Ave.	A-2	Danherb Garage	20	Drl	195	6	Inwood limestone	T	..	40	F	..	Intermittent operation. Depth to bedrock, 65 feet.
B33	4234 Bronx Blvd.	B-2	Caldwell Products, Inc.	100	Drl	460	8-6	do.	T	..	50	AC	33 2- 9-51	Depth to bedrock, 25 feet. Static level reported to be about 70 feet.
B34	612 E. 233d St.	B-2	Mayer's Restaurant	100	Drl	630	6	do.	..	..	35	AC	..	Depth to bedrock, 60 feet. For log see table 6.
B35	1 E. 168th St.	B-1	Jerome Swimming Pool	60	Drl	363	..	do.	..	..	1	..	..	Well abandoned. Depth to bedrock, 22 feet.
B36	517 E. 132d St.	A-1	Crystal Spring Water Co.	20	Drl	452	6	do.	..	..	35	..	..	Depth to bedrock, unknown.
B37	2136 Blackrock Ave.	A-2	George Gowan	40	Drl	100	6	Manhattan schist	..	..	9	..	..	do.
B38	2431 Webster Ave.	B-2	E. Gitto	40	Drl	105	..	Inwood limestone (?)	..	..	30	..	..	Depth to bedrock, about 25 feet.
B39	Center line of Bronx-Whitestone Bridge, about 1,650 feet west of Old Ferry Point	A-2	Triborough Bridge Authority	2	..	92	..	..	..	..	..	..	..	Test boring. Depth to bedrock, 65 feet.
B40	780 E. 133d St.	A-2	Greis Reproducer Corp.	15	Drl	900	8	Manhattan schist	J	..	30	C	1,100 1950	Drawdown reported to be 192 feet after pumping 8 hours at 30 gallons per minute.
B41	1900 Hennessey Pl.	B-2	Joseph Fera	100	Drl	98	6	Fordham gneiss	S	..	5	..	..	Depth to bedrock, 4 feet. Static water level, 20 feet.
B42	1430 Unionport Rd.	B-2	Park Abbey Funeral Clapel, Inc.	30	Drl	140	6	Manhattan schist	T	..	10	AC	69 1- 4-51	Depth to bedrock, 25 (?) feet.
B43	2550 Boston Rd.	B-2	Miller Bros. Service Station	130	Drl	218	8-6	do.	..	..	30	F	..	Depth to bedrock, 33 feet.
B44	2221 Boston Rd.	B-2	Pelham Minute Auto Laundry	100	Drl	250	8-6	do.	..	..	12	F	..	Depth to bedrock, 27 feet.
B45	1275 Jerome Ave.	B-1	Smiling Jack's Auto Laundry	60	Drl	70	6	Inwood limestone	J	18	18	F	..	
B46	Highbridge R.R. yards, nr. Sedgwick Ave.	B-1	New York Central R.R.	10	Drl	200(?)	14	Inwood limestone (?)	T	250	250	F	2,400 8- 3-50	Depth to bedrock, 72 feet. Data uncertain. Abandoned, high chloride content.
B47	2008 Westchester Ave.	A-2	Newbold Garage, Inc.	20	Drl	210	6	Manhattan schist	T	15	15	F	37 1- 4-51	
B48	2534 E. 177th St.	A-2	Finkel Umbrella Frame Co., Inc.	10	Dug	12	60	Pleistocene sand	S	..	50	F	24 1- 9-45	

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
B49	236 E. 138th St.	A-1	Peller Corp.	15	Drl	225	8	Inwood limestone	J	..	60	F	..	Depth to bedrock, 35 feet.
B50	7 West Bedford Park Blvd.	B-2	Bedford Auto Laundry	155	Drl	250	6	Fordham gneiss	T	..	35	F	..	Depth to bedrock, 40 (?) feet.
B51	1440 Westchester Ave.	A-2	Spic & Span Auto Laundry, Inc.	10	Drl	350	6	Manhattan schist	..	..	15	F	..	
B52	3896 Park Ave.	B-2	Modern Carpet Cleaning & Storage Corp.	40	Drl	258	8(?)	Inwood limestone	T	250	150	..	..	Location uncertain.
B53	3040 Webster Ave.	B-2	French-American Reeds Mfg. Co., Inc.	70	Drl	360	12-8	do.	T	100	70	AC	..	Temperature of water, 54° F. Well reported to yield 150 gpm during 3 hour test. For log see table 6.
B54	2910 Third Ave.	A-1	Meisels Coats and Dresses	20	Drl	133	8-6	do.	T	..	65	AC	..	Temperature of water, 59° F. For log see table 6.
B55	894 Whittier St.	A-2	Randall Wine Vinegar Co.	10	Drl	210	2(?)	Manhattan schist	T	20	5	C	..	Length of casing, 40 feet.
B56	3339 Park Ave.	A-2	L. Daitch & Co.	20	Drl	215	8	Inwood limestone (?)	T	300	80	AC,C	33 5- 9-39	Static level about 40 feet.
B57	W. 230th and Exterior Sts.	B-2	..	2	Drl	31	2½	Pleistocene deposits	..	..	..	..	..	Test boring No. 2. For log see table 6.
B58	Manida and Ryawa Aves.	A-2	Hunts Point Sewage Treatment Plant	20	Drl	45	2½	Manhattan schist	..	..	..	..	..	Test boring No. A7-2. Depth to bedrock 34 feet.
B59	Ryawa and Halleck Sts.	A-2	do.	8	Drl	88	..	do.	..	..	..	..	..	Test boring, for log see table 6.
B60	Foot of Connor St. and Hutchinson River	A-3	do.	4	Drl	29	..	do.	..	..	..	..	..	Test boring. Depth to bedrock, 13 feet.
B61	Wales Ave. and E. 141st St.	A-2	Lincoln Hospital	42	Drl	33	..	do.	..	..	..	..	..	Test boring. Depth to bedrock, 13 feet.
B62	Morris Park and Seminole Aves.	B-2	East Bronx General Hospital	63	Drl	18	..	do.	..	..	..	..	..	Test boring. Depth to bedrock, 5 feet.
B63	Arthur Ave. and E. 186th St.	B-2	Arthur Ave. Market	73	Drl	38	..	Fordham gneiss	..	..	..	..	..	Test boring. Depth to bedrock, 36 feet.
B64	E. 188th St. and Webster Ave.	B-2	Fordham Riverdale Health Center	50	Drl	44	..	Manhattan schist	..	..	..	..	..	Test boring. 0-39 till; 39-44 bedrock.
B65	Canal Pl and 135th St.	A-1	Police Department Stable	5	Drl	49	..	Inwood limestone	..	..	..	..	..	Test boring, for log see table 6.
B66	Palisade Ave. and 232nd St.	B-1	Seton Hospital	125	Drl	43	..	do.	..	..	..	..	..	Test boring. Depth to bedrock, 29 feet.
B67	Bruckner Blvd. nr. E. Tremont Ave.	B-3	Bruckner Blvd. Underpass	46	Drl	47	..	Manhattan schist	..	..	..	..	..	Test boring. Depth to bedrock, 36 feet.
B68	Gildersleeve and Soundview Aves.	A-2	Hunts Point Sewage Treatment Plant	20	Drl	25	..	do.	..	..	..	..	..	Test boring. Depth to bedrock, 19 feet.
B69	Bronx River about 1500 ft west of Patterson Ave.	A-2	do.	0	Drl	76	..	do.	..	..	..	..	..	Test boring, for log see table 6.

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
B70	Brush Ave. and Brackner Blvd.	A-2	Unionport Bridge	13	Drl	83	..	Pleistocene deposits	..	..	..	..	..	Test boring. For log see table 6.
						NEW	YORK	COUNTY						
Ny2	251 Broadway	A-1	Trinity Operating Co.	10	Drl	66	12	Pleistocene sand	T	350	350	AC	..	Used only during the summer months.
Ny3	17 N. Moore St.	A-1	Merchants Refrigerating Co.	10	Drl	47	8	do.	S	600 and 800	..	C	2,100 7- 6-46	Ny3-9 all connected to common pumps. Temperature of water on 7-6-46, 63° F. Combined yield from all wells 800 gallons per minute. For chemical analysis see table 5. Pump capacities uncertain.
Ny4	do.	A-1	do.	10	Drl	46	8	do.	S	600 and 800	..	C	..	
Ny5	do.	A-1	do.	10	Drl	40	8	do.	S	600 and 800	..	C	..	
Ny6	do.	A-1	do.	10	Drl	49	8	do.	S	600 and 800	..	C	..	
Ny7	do.	A-1	do.	10	Drl	44	8	do.	S	600 and 800	..	C	..	
Ny8	do.	A-1	do.	10	Drl	38	10	do.	S	300 and 100	..	C	..	
Ny9	do.	A-1	do.	10	Drl	40	10	do.	T	600	..	C	..	
Ny10	280 Broadway	A-1	The New York Sun, Inc.	35	Drl	52	8	Pleistocene gravel	T	52	52	C	43 2- 5-42	
Ny11	477 Broome St.	A-1	P. Margarella Candy Co.	15	Drl	52	6	Pleistocene sand	T	35	35	C	..	Sealed by Bureau of Foods and Drugs. Ny12, nearby.
Ny12	do.	A-1	do.	15	Drl	52	6	do.	R	70	70	C	49 10- 9-44	Near Ny11.
Ny13	385 Canal St.	A-1	D. Arnold Co.	15	Drl	55	10	do.	R	..	40	C,F	96 2-16-42	Bedrock reported at bottom of well.
Ny16	240 Church St.	A-1	Deering-Millikan Co., Inc.	20	Drl	56	8	do.	T	160	160	AC	107 1-22-40	Used only during the summer months.
Ny17	85 Cliff St.	A-1	J. Chatillon & Sons	25	Drl	42	4	do.	S	50	50	F	67 9-25-40	
Ny18	175 E. Houston St.	A-2	S. Ershowsky & Sons., Inc.	40	Drl	46	8	do.	R	..	75	..	..	Well not in use.
Ny19	37 Essex St.	A-2	Isaac Gellis, Inc.	40	Drl	32	12	do.	S	..	..	..	..	do.
Ny20	166 Essex St.	A-2	Essex St. Auto Car Wash Co., Inc.	30	Drv	43	2	do.	R	15	15	F	58 1-23-50	
Ny21	91 Fulton St.	A-1	150 William St. Corp.	25	Drl	57	8	do.	T	175	220	AC	233 2- 3-42	Used only during the summer months. Iron content, 2.7 parts per million.

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
Ny22	372 Greenwich St.	A-1	Max Ams, Inc.	10	Drl	60	3	do.	R,St	60	60	C,F	950 9-24-42	
Ny23	402 Greenwich St.	A-1	Greenwich Refrigerating Co.	10	Drl	35	6	Pleistocene sand and gravel	S	70	70	C	2050 3-23-50	For log see table 6.
Ny24	627 Greenwich St.	A-1	Ciba Co., Inc.	10	Drl	49	6	Pleistocene sand	T	250	95	AC	62 6- 8-42	Used only during the summer months. Ny130, nearby.
Ny26	313 Hudson St.	A-1	Henry Heide, Inc.	10	Dug	80	72	Pleistocene sand	R	1000	..	AC,F	150 6-12-44	Depth to bedrock, probably 80 feet. Four abandoned wells at site.
Ny27	do.	A-1	do.	10	Dug	80	72	do.	R	450	..	AC,F	..	
Ny28	do.	A-1	do.	10	Drl	..	8	do.	R	500	..	..	..	Well is for emergency use.
Ny32	395 Hudson St.	A-1	395 Hudson St. Corp.	15	Drl	70	14	Pleistocene gravel	T	400	400	C	160 1-15-43	
Ny33	85 Jane St.	A-1	Lucy Ricciardi, Inc.	15	Drl	40	6	Pleistocene sand	T	40	25	C	64 3-31-42	
Ny34	2 Lafayette St.	A-1	Court Square Building Corp.	25	Drl	100	5	Pleistocene gravel	T	250	250	AC	5-25-39 1400	Used only during the summer months. For log see table 6.
Ny35	70 Laight St.	A-1	Fairchild Bros. & Foster	10	Drl	39	6	do.	S,St	100	100	C	2800 6-19-16	
Ny36	do.	A-1	do.	10	Drl	38	8	do.	S,St	100	100	C	..	Near Ny35.
Ny37	do.	A-1	do.	10	Drl	61	10	do.	S	..	100	C	..	do.
Ny40	98 Morton St.	A-1	Baker, Williams Warehouse Corp.	10	Drl	52	8	Pleistocene sand	T	150	150	AC	2-11-42 140	Used only during the summer months. For log see table 6.
Ny41	23 Park Row	A-1	Downtown Bowling Academy, Inc.	30	Drl	54	8	do.	R	125	158	AC	38 3- 4-42	Depth to bedrock, 76 feet. For log see table 6.
Ny42	358 Pearl St.	A-1	O. J. Maigne Co.	20	Drl	36	6	do.	R,St	400	400	C,F	150 2- 4-42	Ny43-45, nearby.
Ny43	do.	A-1	do.	20	Drl	36	6	do.	R,St	400	400	C,F	..	Near Ny42.
Ny44	do.	A-1	do.	20	Drl	36	6	do.	R,St	500	500	C,F	..	do.
Ny45	do.	A-1	do.	20	Drl	36	4	do.	R,St	500	500	C,F	..	do.
Ny46	391 Pearl St.	A-1	A. Heller Heat Treating Co.	20	Drl	52	6	do.	T	69	85	C,F	247 4-21-43	Near Ny48.
Ny47	401 Pearl St.	A-1	Brown Derby Garage	20	Drv	18	2	Pleistocene gravel	J	50	..	F	82 4-13-50	do.
Ny48	406 Pearl St.	A-1	Bingham Bros. Co.	20	Drl	46	4	Pleistocene sand	S	111	111	C	360 2- 6-42	Ny46, 47, 49, 50, and 51, nearby.
Ny49	do.	A-1	do.	20	Drl	46	4	do.	S	111	111	C	..	Near Ny48.
Ny50	do.	A-1	do.	20	Drl	46	4	do.	S	..	36(?)	C	..	Well not in use at present. Near Ny48.
Ny51	do.	A-1	do.	20	Drl	46	4	do.	S	..	36(?)	C	..	do.

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
Ny52	231 St. Nicholas Ave.	B-2	Fred Hulberg, Inc.	30	Drl	70	4	do.	R	30	30	F	54 7-10-44	
Ny53	11 Sheriff St.	A-2	Standard Laundry Service, Inc.	30	Drl	48	10	Pleistocene gravel	T	200	200	L	31 10-31-38	Well not used. For chemical analysis see table 5. For log see table 6.
Ny54	24 Vandewater St.	A-1	Brooklyn Bridge Freezing & Cold Storage Co.	52	Drl	114	6	Pleistocene sand and gravel	T	125	125	C,F	9500 6- 4-46	Ny55 and 56, nearby.
Ny55	do.	A-1	do.	25	Drl	87	8	do.	T	350	350	C,F	2300 6- 4-46	Near Ny54.
Ny56	do.	A-1	do.	25	Drl	83	8	do.	T	..	..	C,F	5550 6- 4-46	Near Ny54. For chemical analysis see table 5.
Ny57	200 Varick St.	A-1	Parker Kalon Corp.	20	Drl	65	8	Pleistocene sand	T	200	200	C	61 11-27-36	For chemical analysis see table 5.
Ny61	295 Water St.	A-2	Atlantic Coast Fisheries	5	Drl	70	8	do.	T	110	..	C	10,150 3-7-40	Near East River.
Ny62	463 West St.	A-1	Bell Telephone Laboratories	10	Drl	90	..	do.	S	60	50	F	440 2-11-42	
Ny64	23 Wooster St.	A-1	The Bianchi Co.	15	Drv	31	2	do.	S	30	30	C	62 8-12-42	10-inch well, 31 feet deep, same property. Ny65, nearby.
Ny65	do.	A-1	do.	15	Drl	31	4	do.	S	30	30	C	..	Near Ny64.
Ny67	24 First Ave.	A-2	First Ave. Bathing Corp.	35	Drv	22	2	do.	S	15	..	S	99 9-18-41	Two other wells, same property.
Ny70	24 Second Ave.	A-2	Second Ave. Baths Corp.	40	Drl	75	8	do.	T	250	250	S	88 2-19-42	Two other wells, same property, not in use. For chemical analysis see table 5.
Ny74	18 Walker St.	A-2	New York Telephone Co.	15	Drl	160	5	do.	T	250	250	AC	..	
Ny75	636 11th Ave.	B-2	Midtown Industrial Bldg.	20	Drl	175	10	Manhattan schist (?)	A	600	800	..	..	Well not used at present.
Ny76	do.	B-2	do.	20	Drl	125	10	do. (?)	A	400	500	..	..	do.
Ny77	223 E. 2d St.	A-2	11th Ward Baths, Inc.	20	Drv	60	2	Pleistocene sand	S	..	30	S	48 2-19-42	
Ny79	328 E. 103d St.	B-2	E. Greenbaum & Co.	10	Drl	36	4	do.	R,St	60	35	C	1600 6- 5-42	
Ny80	do.	B-2	do.	10	Drl	36	4	do.	R	60	..	C	..	
Ny81	421 E. 107th St.	B-2	Wayne Milk Corp.	10	Drl	30	8	do.	T	100	80	C	76 6- 5-42	Chloride content, 350 parts per million on 1-30-39. Well abandoned in 1946.
Ny82	167 E. 127th St.	B-2	Stahl-Meyer, Inc.	15	Drl	30	6	do.	T	125	125	C,F	84 1952	Four other wells on property reported to have gone dry.
Ny83	638 W. 30th St.	B-1	J. T. Stanley Co.	10	Dug	25	75	Pleistocene gravel	S,St	250	250	C	326 9-21-39	Chloride content on 1-2-42, 2,350 ppm.
Ny84	268 W. 125th St.	B-2	Charles Weisbecker, Inc.	30	Drl	30	6	Pleistocene sand	R	40	40	C,F	32 2- 6-42	For chemical analysis see table 5.

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
Ny85	138 W. 124th St.	B-2	Washington Heights Laundry, Inc.	30	Drl	150 (?)	6	do.	T	250	250	L	101 6-11-52	Depth of well, uncertain. Ny25 nearby, 25 feet deep.
Ny86	do.	B-2	do.	30	Drl	..	6	do.	S	250	350	L	..	do.
Ny87	do.	B-2	do.	30	Drl	..	6	do.	S	350	350	L	..	do.
Ny89	527 W. 125th St.	B-2	Muller Dairies, Inc.	35	Drl	35	6	do.	T	100	90	C,F	42 6- 3-43	For chemical analysis see table 5.
Ny90	do.	B-2	do.	35	Drl	35	4	do.	R,St	90	40	C,F	..	
Ny91	430 W. 126th St.	B-2	Purity Bakeries, Inc.	35	Drl	75	6	do.	T	100	100	C,F	40 1952	
Ny93	574 W. 130th St.	B-2	Marchiony Spumoni Corp.	40	Drl	40	6	do.	..	..	..	..	..	Not in use, reported to have gone dry in 1940.
Ny94	5134 Broadway	C-3	Bway. Minit Auto Laundry, Inc.	20	Drl	39	6	do.	T	50	50	F	..	Bedrock penetrated at 44 feet.
Ny95	349 Canal St.	A-1	City Canal Corp.	15	Drv	55	1½	Pleistocene sand and gravel	T	15	15	F	74 9-19-50	
Ny96	22 Little West 12th St. Nassau	A-1	Ideal Auto Service	10	Drl	33	8	Pleistocene sand	S	10	14	F	196 1-23-50	For chemical analysis see table 5.
Ny97	113 Nossau St.	A-1	Vesuvius Pizzeria, Inc.	30	Drl	65	3	Pleistocene sand	J	80	40	AC	..	Screen set from 61 to 65 feet.
Ny98	23 Thomas St.	A-1	Cannon Mills, Inc.	30	Drl	46	8	do.	T	50	60	C	120 5- 2-50	
Ny99	58 Worth St.	A-1	Southeastern Cottons, Inc.	35	Drl	60	8	do.	T	50	70	C	305 5- 2-50	Near Ny 98.
Ny100	37 Thomas St.	A-1	do.	35	Drl	41	8	do.	T	50	60	C	120 5- 2-50	do.
Ny101	80 Worth St.	A-1	Bates Fabrics, Inc.	35	Drl	51	8	do.	T	50	60	C	270 5- 2-50	Ny152 nearby. For chemical analysis see table 5.
Ny102	403 E. 60th St.	B-2	St. Charles Garage, Inc.	40	Drv	14	1¼	Pleistocene gravel	S	10	5	F	..	
Ny103	561 11th Ave.	B-2	Crown Gas Station, Inc.	10	Drl	148	6	Manhattan schist	S	10	..	F	525 9-19-50	Depth to bedrock, 40 feet.
Ny105	111 Barclay St.	A-1	John Minder & Son	5	Drl	69	12	Pleistocene sand	T	100	200	C	310 1952	Temperature of water, 66° F. For log see table 6. Screen set from 53 to 69 feet.
Ny108	Christie and Delancey Sts.	A-2	Libby Baths, Inc.	45	Drl	402	..	..	..	..	..	..	..	Depth to bedrock, 150 feet. For log see table 6.
Ny109	do.	A-2	do.	45	Drl	177	..	..	..	..	..	..	..	Depth to bedrock, 177 feet. For log see table 6.
Ny110	220 Greenwich St.	A-1	A. Peltz & Son	10	Drl	56	6	Pleistocene sand	..	75	30	C	..	Temperature of water 69° F. For log see table 6.
Ny111	45 John St.	A-1	Windsor Cafeteria	25	Drl	70	8	do.	..	70	70	AC	184 1952	Temperature of water, 71° F. For log see table 6.
Ny112	262 First Ave.	A-2	National City Bank	20	Drl	90	6	Pleistocene sand and gravel	..	40	..	AC	..	do.

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
Ny113	150 William St.	A-1	Royal Insurance Co.	25	Drl	57	8	Pleistocene sand	T	..	210	AC	..	Screen set from 37 to 57 feet.
Ny114	150 Broadway	A-1	John Wanamaker	30	Drl	77	6	Pleistocene sand and gravel	..	..	12	..	..	Insufficient yield. Temperature of water 76° F. Depth to bedrock, 77 feet. For log see table 6.
Ny117	8th Ave. and 14th St.	A-1	New York Savings Bank	25	Drl	40	8	Pleistocene sand	..	..	50	AC	..	Well abandoned, insufficient yield.
Ny119	261 Mulberry St.	A-2	Hawley & Hoops Candy Co.	45	Drl	65	6	do.	T	85	85	C,F	..	Well abandoned.
Ny123	632 W. 125th St.	B-2	Sheffield Farms Co., Inc.	15	Drl	55	12	do.	T	150	225	C,F	215 3-31-42	Intermittent operation. Chloride content 10 parts per million on 4-24-36.
Ny124	do.	B-2	do.	15	Drl	55	12	do.	T	150	225	C,F	134 1952	
Ny125	do.	B-2	do.	15	Drl	60	10	do.	T	450	225	C,F	..	
Ny130	644 Greenwich St.	A-1	Vita Food Products, Inc.	10	Drv	35	2	do.	R	..	50	C	126 1-24-50	Ny24, nearby.
Ny131	do.	A-1	do.	10	Drv	35	2	do.	R	..	50	C	22 3-31-42	
Ny132	do.	A-1	do.	10	Drv	35	2	do.	R	..	50	C	..	Intermittent operation.
Ny133	313 Geenwich St.	A-1	Heermance Storage & Refrigerating Co.	15	Drl	78	12-8	do.	..	..	75	C	..	Ny134 and 135, nearby. For log see table 6.
Ny134	do.	A-1	do.	15	Drl	71	10-8	do.	..	..	35	C	..	Near Ny133. Ny134 and 135 on common suction line.
Ny135	do.	A-1	do.	15	Drl	31	8	do.	..	..	35	C	..	do.
Ny137	51st St. and Park Ave.	B-2	Ambassador Hotel	70	Drl	620	6	Manhattan schist	T	..	70	AC	..	Depth to bedrock, 49 feet. Drawdown reported to be 305 feet when pumping at 70 gallons per minute.
Ny138	Polo Grounds	B-2	National Exhibition Club	20	Drl	357	6	do. (?)	T	25	25	1	..	Depth to bedrock, 45 feet. Drawdown reported to be 219 feet after 8 hours of pumping at 25 gallons per minute. For log see table 6.
Ny139	408 W. 207th St.	C-2	Crystal Aquatic Arena	15	Drl	310	8	Inwood limestone	T	50	50	S	98 5-17-50	Depth to bedrock, 67 feet. Drawdown reported to be 215 feet after 8 hours of pumping at 50 gallons per minute.
Ny140	26 Cortlandt St.	A-1	East River Savings Bank	20	Drl	68	8	Pleistocene sand	..	..	..	..	..	Well abandoned. Yield less than 200 gallons per minute.
Ny141	78 Ridge St.	A-2	Phil Silvershein Corp.	25	Drl	60	10	do.	T	..	120	C	..	Temperature of water, 57° F. For log see table 6.
Ny142	53-55 Worth St.	A-1	Pinkham & Egelhoff	20	Drl	50	8	do.	T	30	30	AC	141 9- 6-50	Screen setting 40 to 50 feet.
Ny143	121 Varick St.	A-1	S. F. Whitman & Son	15	Drl	40	4	do.	J	30	15	AC	79 10- 6-50	Screen set from 34 to 40 feet.
Ny145	37-43 Greene St.	A-1	Eastern Doll Corp.	20	Drl	48	6	do.	T	140	60	C	42 7-18-50	Near Ny11. Screen set from 38 to 48 feet.

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
Ny146	555 Grand St.	A-2	Launder Car Wash	15	Drl	48	6	do.	..	..	50	F	28 3- 3-50	Jonathan Water Co., probably at same location. Temperature of water, 59° F. For log, see table 6.
Ny147	410 E. 54th St.	B-2	Mammoth Garage	30	Drl	4(?)	6	do.	S	25	15	F	223 2-23-50	
Ny148	89 Chrystie St.	A-2	Chrystie St. Garage	40	Drv	35	2	do.	..	15	8	F	154 5- 1-50	
Ny149	395 Broadway	A-1	Boardwalk Realty Corp.	20	Drl	38	4	do.	J	40	15	AC	202 6-23-50	
Ny150	Third Ave. and 130th St.	B-2	Test boring 3A, Third Ave. Bridge	6	Drl	106	..	Inwood limestone	..	..	..	..	..	Depth to bedrock, 89 feet.
Ny151	1361 Amsterdam Ave.	B-2	Interboro Fur Storage Corp.	35	Drl	40	6	Pleistocene sand	..	220	200	C	65 9- 8-44	Near Ny91.
Ny152	88 Worth St.	A-1	Marshall Field & Co.	35	Drl	50	8	do.	T	60	50	AC	82 9- 6-50	Used 8 hours daily. Screen set from 40 to 50 feet. Near Ny101.
Ny153	585 Water St.	A-2	Benson & Hedges	20	Drl	60	..	do.	T	150	150	C,F	85 2- 7-52	
Ny154	25th St. nr. 10th Ave.	A-1	..	10	Drl	63	..	do.	..	..	..	..	..	Depth to bedrock, 63 feet. For log see table 6.
Ny155	Park Ave. and 42nd St.	B-2	..	55	Drl	420	18-8	Manhattan schist	..	..	30	..	..	Depth to bedrock, 15 feet. Drilled prior to 1901.
Ny156	638 W. 47th St.	B-2	Dales Car Washers	10	Drl	132	6	do.	T	50	27	F	..	
Ny157	2 E. 55th St.	B-2	Hotel St. Regis	60	Drl	100	6	do.	T	30	15	AC	..	Depth to water reported to be about 30 feet.
Ny158	423 W. 126th St.	B-2	Shensey Co.	35	Drl	90	6	Pleistocene deposits	J	30	15	AC,F	37 4- 8-52	Near Ny91.
Ny159	200 Delancey St.	A-2	Coberta Realty Corp.	20	Drl	60	10	do.	S	150	125	C,AC	93 4- 2-52	Test boring. Depth to water reported to be 10 feet.
Ny160	E. 99th St., 200 feet east of 1st Ave.	B-2	East Harlem General Hospital	3	Drl	149	..	Inwood limestone	..	..	..	..	..	Test boring. Depth to bedrock about 142 feet. For log see table 6.
Ny161	Madison Ave., 50 feet north of E. 25th St.	A-2	Appellate Division Court Building	30	Drl	23	..	Manhattan schist	..	..	..	..	..	Test boring. Depth to bedrock about 14 feet. For log see table 6.
Ny162	Northwest cor. of 8th Ave. and W. 142nd St.	A-2	Harlem Retail Market	20	Drl	112	..	Inwood limestone	..	..	..	..	..	Test boring. Depth to bedrock about 105 feet. For log see table 6.
Ny163	Broadway, 300 feet north of Dyckman St.	C-2	Inwood Branch Library	20	Drl	73	..	do.	..	..	..	..	..	Test boring. Depth to bedrock, 41 feet. For log see table 6.
Ny164	Fort Washington Ave., 200 ft. north W. 163rd	C-2	Nightingale Hospital	140	Drl	48	..	Manhattan schist	..	..	..	..	..	Test boring. Depth to bedrock, 26 feet. For log see table 6.
Ny165	Broadway and Harlem River	C-3	Broadway Bridge	5	Drl	59	..	Inwood limestone	..	..	..	..	..	Test boing SA4. For log see table 6.
Ny166	380 W. 12th St.	A-1	Hubert Warehouses	10	Drl	40	6	Pleistocene deposits	T	65	65	AC	..	One other well on property, nearby. Drilled in 1951.

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
						RICHMOND COUNTY								
R1	6006 Amboy Rd.	B-2	J. M. Sprague	15	..	35	..	Pleistocene sand	..	..	4	D	16 5-15-42	
R4	Arthur Kill Rd. and Ellis La.	B-2	Socony Vacuum Oil Co., Inc.	10	Dug	8	26	do.	..	..	..	D	42 5-25-45	Intermittent operation. Abandoned in 1952.
R5	169 Arthur Kill Rd.	B-3	Richmond Floral Co., Inc.	5	Drl	50	6	do.	S	50	50	I	..	do.
R6	317 Bay St.	C-4	Automatic Auto Laundry	15	Drl	50	6	Pleistocene sand and gravel	..	40	40	F	81 3-23-50	do.
R7	465 Bay St.	C-4	New Method Service Co.	10	Drl	50	10	do.	T	250	250	L	24 4- 8-42	For chemical analysis see table 5. For log see table 6. Temperature of water 57° F.
R8	560 Bay St.	C-4	Stapar Theatres, Inc.	15	Drl	75	..	Pleistocene sand	T	250	200	AC	14 4-11-42	For chemical analysis see table 5.
R10	789 Henderson Ave.	C-3	Clay Smith Textile Corp.	18	Drl	87	8	Pleistocene sand and gravel	S	200	260	C	15 4- 7-42	Four other wells, same property, ranging in depth from 56 to 92 feet.
R14	164 Canal St.	C-4	Park Lanes, Inc.	30	Drl	42	6	do.	S	35	40	AC	20 4- 8-42	For chemical analysis see table 5. For log see table 6. Temperature of water 57° F.
R15	191 Canal St.	C-4	Rubsam & Horrmann Brewing Co.	50	Drl	800	10	Serpentine	T	300	200	C,F	20 3- 8-50	Depth to bedrock, probably 70 feet. R16 and 73, nearby.
R16	do.	C-4	do.	50	Drl	600	12	do.	T	300	200	C	..	Near R15.
R17	685 Cary Ave.	C-3	Blue White Laundry Co., Inc.	30	Drl	74	8	Pleistocene sand and gravel	T	200	350	L	14 4- 7-42	For chemical analysis see table 5. For log see table 6. Temperature of water 54° F.
R18	92 Chestnut St.	C-4	Ansbacher Siegle Corp.	45	Drl	139	12	do.	T	300	368	P	..	For log see table 6. Temperature of water 56° F.
R19	169 Edgewater St.	C-4	Richmond Ice Co.	10	Drl	180	10-4	Pleistocene or Cretaceous sand ?	T	75	70	C	1550 5-21-45	Two other wells, same property. For chemical analysis see table 5. Screen set from 160 to 180 feet.
R22	187 Edgewater St.	C-4	L. A. Dreyfus Co.	15	Drl	177	8	?	T	52	40	P	1550 9-28-42	Well reported to end in bedrock at 177 feet. Iron content of water 5 parts per million.
R24	23 Gordon St.	C-4	Richmond Ice Co.	60	Drl	32	6	Pleistocene sand	S	..	900	C	..	Four other wells, same property, reported to be about 30 feet deep. Combined yield, 600 gallons per minute. Data uncertain.
R29	54 Greenleaf Ave.	C-3	Stapleton Service Laundry, Inc.	35	Drl	99	14	Pleistocene gravel	T	300	300	L	20 4- 7-42	For chemical analysis see table 5.
R30	1965 Richmond Terrace	C-3	Pontin Literage & Transportation Corp.	5	Drl	93	4	Pleistocene sand and gravel	S	260	260	C	27 3-24-39	For chemical analysis see table 5.
R35	1 Nassau Place	B-2	Nassau Smelting & Refining Co.	15	Drl	53	8-6	Pleistocene sand	T	110	60	..	21 4-11-42	Three other wells on property, ranging in depth from 42 to 60 feet. R70 nearby.

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
R39	330 Tompkins Ave.	C-4	Louis DeJonge & Co.	60	Drl	102	6	Pleiistocene gravel	R	..	60	..	19 4- 9-42	One other well on property, 110 feet deep.
R41	1111 Woodrow Rd.	B-2	Watchtower Bible & Tract Society, Inc.	150	Drl	159	8	Cretaceous sand and gravel	T	100	150	I	9 4- 7-52	For chemical analysis see table 5. One other well about 135 feet deep on this property.
R42	do.	B-2	do.	150	Drl	400	8	..	..	..	..	..	..	Deep test well. For log see table 6.
R43	Foot of Lincoln Ave.	B-3	Midland Operating & Amusement Co.	5	Drl	44	10-3	Pleistocene sand	S	400	200	S	20 9-12-44	Seasonal operation. Chloride content of water, 133 parts per million on 6-10-42.
R44	97 Jewett Ave.	C-3	Consolidated Ice Co.	10	Drl	67	8-6	Pleistocene sand and gravel	..	..	250	C	16 6-10-42	Two other wells on property, 52 to 59 feet deep.
R47	28 Grove Ave.	C-3	Speed King Auto Laundry	20	Drl	40	..	Palisade diabase ?	..	..	..	..	..	Well abandoned, low yield. Water reported to be salty. Depth to bedrock, 13 feet.
R48	Forest Ave.	C-3	Forest Lane Ice Cream Co.	20	Drl	166	8	Palisade diabase and Newark group	..	..	2	..	..	Well abandoned, low yield, Depth to diabase bedrock, probably 30 feet.
R51	Seguine Ave.	B-2	S. S. White Dental Co.	5	Drl	41	6	Pleistocene sand and gravel	..	..	80	C	700 4-10-42	Well not used, high chloride content. Two other wells reported on this property.
R54	50 Murray St.	B-2	Beinert's Ice Co., Inc.	20	Drl	229	..	Cretaceous sand	..	..	200	C	2 4-11-42	For chemical analysis see table 5. For log see table 6.
R55	Costleton Ave. and Rector St.	C-3	New York City Board of Transportation	18	Drl	81	12	Pleistocene sand and gravel	T	300	310	F	..	For log see table 6. Specific capacity, 34. Temperature of water 52° F.
R56	Oakwood Beach	B-3	New York City Dept. of Public Works	2	Drl	102	..	..	..	..	..	..	..	Test boring. For log see table 6.
R57	Center St., near St. Patrick's Pl.	B-3	do.	30	Drl	181	..	..	..	..	..	..	..	do.
R58	Rockland and Brielle Aves.	C-3	do.	295	Drl	47	..	..	..	..	..	..	..	do.
R59	Bodine St. and Richmond Terrace	C-3	do	2	Drl	105	..	..	..	..	..	..	..	do.
R60	East shore of Great Fresh Kills	B-2	do.	1	Drl	76	..	..	..	..	..	..	..	do.
R61	West of intersection of Ellis St. and Nassau Pl.	B-2	Atlantic Terracotta Co.	5	Drl	163	6	Cretaceous sand	..	..	140	..	..	For log see table 6.
R62	Margaret St., west of Giffords La.	B-3	New York City Dept. of Public Works	65	Drl	51	..	..	..	..	..	..	..	Test boring. For log see table 6.
R63	Hylan Blvd. and Emmet Ave.	B-3	New York City Dept. of Water Supply, Gas and Electricity	10	Drl	77	6	Pleistocene sand and gravel	..	..	120	PS	45 5-26-50	Blvd. Sta. No. 1. Well No. 7. Depth to bedrock, 270 feet. For log see table 6. Composite chloride from 14 wells pumping 2 mgd. Wells on common suction. For chemical analysis see table 5.
R64	Hylan Blvd. and New Dorp La.	B-3	do.	10	Drl	78	6	do.	..	..	..	PS	11 5-26-50	Blvd. Sta. No. 2. Composite chloride of 14 wells on Well No. 9. For log see table 6. Common suction.

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
R65	Hylan Blvd. and Buel Ave.	C-3	do.	10	Drl	79	4-6	do.	..	..	125	PS	45 5-25-50	Blvd. Sta. No. 3. Composite chloride on 14 wells on Well No. 12. For log see table 6. Common suction.
R66	Hylan Blvd. and Evergreen Ave.	C-3	do.	12	Drl	96	6	do.	..	..	700	PS	15 5-24-50	Blvd. Sta. No. 4. Composite chloride of 14 wells on Well No. 9. For log see table 6. Common suction.
R67	East end of Goethals Bridge	C-2	Port of New York Authority	3	Drl	51	..	..	..	..	..	..	..	Test boring. For log see table 6.
R68	Near south end of Bayonne Bridge	C-3	do.	34	Drl	43	..	..	..	..	..	..	..	do.
R69	Richmond Ave. and Signs Rd.	C-3	Bulls Head well field New York City Dept. of Water Supply, Gas and Electricity	20	Drl	95	6	Pleistocene sand and gravel	..	3500	1500	PS	..	For log see table 6. About 30 wells, all on common suction. Combined capacity estimated at 2 million gallons daily.
R70	1 Nassau Pl.	B-2	Nassau Smelting & Refining Co.	15	Drl	353	..	..	..	..	..	..	..	R35, nearby. For log see table 6.
R71	1 mile north of Seguine Point	B-2	..	30	Drl	147	..	..	..	..	..	..	..	Test boring for bridge. Location uncertain. For log see table 6.
R72	Near ferry slip at Tottenville	B-1	Harry Chassey	20	Drl	173	..	Cretaceous sand	..	..	..	D	..	Location uncertain. For log see table 6.
R73	191 Canal St.	C-4	Rubsam & Horrmann Brewing Co.	50	Drl	80	8	Pleistocene sand and gravel	..	..	10	..	..	Test well. For log see table 6. R15 and 16, nearby.
R74	Cortlandt St. and Haughwout Ave.	C-3	New York City Dept. of Water Supply, Gas and Electricity	20	Drl	80	..	do.	..	..	..	..	..	Test well. For log see table 6. Water reported to be salty.
R75	Forest Ave., 300 feet east of Clove Rd.	C-3	..	85	Drl	85	..	..	..	..	..	..	..	Test boring. Depth to bedrock, 69 feet. For log see table 6.
R76	Forest Ave. and Bway.	C-3	..	115	Drl	89	..	..	..	..	..	..	..	Test boring. Depth to bedrock, 67 feet. For log see table 6.
R77	Bement Ave., 390 feet north of Forest Ave.	C-3	..	120	Drl	16	..	..	..	..	..	..	..	Test boring. Depth to bedrock, 16 feet. For log see table 6.
R78	Forest and Davis Aves.	C-3	..	130	Drl	91	..	..	..	..	..	..	..	Test boring, Depth to bedrock, 97 feet. For log see table 6.
R79	Van Tuyl and York Aves.	C-3	..	120	Drl	44	..	..	..	..	..	..	..	Test boring. Depth to bedrock, 10 feet. For log see table 6.
R80	St. Mark's Pl. and Hyatt St.	C-4	..	110	Drl	37	..	..	..	..	..	..	..	Test boring. Depth to bedrock, 4 feet. For log see table 6.
R81	Borough Pl. and Bay St.	C-4	..	40	Drl	49	..	..	..	..	..	..	..	Test boring. Depth to bedrock, 34 feet. For log see table 6.
R82	Hoffman Island	B-4	New York Quarantine Station	5	Drl	1000	..	..	..	..	..	..	..	Test boring. Depth to bedrock, probably 450 feet. For log see table 6.
R83	Washington Ave., 800 ft. west of Western Ave.	C-2	..	3	Drl	48	..	Pleistocene sand	..	..	..	..	..	Test boring for Goethals Bridge.

Table 7.—Records of selected wells and borings in Bronx, New York, and Richmond Counties (Continued)

Well number	Location	Map coordinates	Owner	Altitude above sea level (feet)	Type of well	Depth (feet)	Diameter (ins.)	Geologic subdivision	Method of lift	Pump cap. (gals. per min.)	Yield (gals. per min.)	Use of water	Chloride (parts per million)	Remarks
R84	564 Lynn St.	B-3	Gaetano Mazzella	10	Drv	45	1½	do.	S	10	10	D	131 12- 7-51	Static level reported to be about 40 feet.
R85	181 Spring St.	C-3	Fortunato Fecci	130	Drv	82	1¼	do.	S	..	..	D	..	Formerly used for drinking. Now used for gardening only.
R86	17 Eddy St. (?)	C-3	W. Kaupe	320	Drl	371	8	Serpentine	..	..	3.5	D	..	Depth to bedrock, 32 feet.
R87	Southeast side of Silver Lake Reservoir	C-3	Test boring No. 7, C113, Board of Water Supply	217	Drl	100	..	do.	..	..	..	..	..	Depth to bedrock, 77 feet.
R88	Hylan Blvd. and Lincoln Ave.	B-3	Grant City well field, New York City Dept. of Water Supply, Gas and Electricity	15	Drl	50-100	4-8	Pleistocene sand	..	..	..	PS	72 1- 4-50	Composite chloride sample from 17 wells, pumping at rate of 2.3 million gallons daily.
R89	Ormond Pl. and Butler Pl.	C-4	Narrows Project	25	..	36	..	Pleistocene deposits	..	..	..	..	..	Test boring No. 3. Depth to water reported to be about 18 feet in 1931. For log see table 6.
R91	Clifton Ave. and Rosebank Pl.	C-4	do.	25	..	40	..	do.	..	..	..	..	..	Test boring No. 4. Depth to water reported to be about 6 feet in 1931. For log see table 6.
R93	Maryland Ave. and White St.	C-4	do.	25	..	52	..	do.	..	..	..	..	..	Test boring No. 6. Depth to water reported to be about 5 feet in 1931. For log see table 6.
R95	Hope Ave., 220 feet west of Bay St.	C-4	do.	35	..	68	..	do.	..	..	..	..	..	Test boring No. 9. For log see table 6.
R98	Wadsworth Rd. and Seagate Rd.	C-4	do.	55	..	143	..	do.	..	..	..	..	..	Test boring No. 1. Depth to water reported to be about 48 feet in 1931. For log see table 6.
R99	Hudson River, 150 feet east of Seagate Rd.	C-4	do.	0	..	114	..	do.	..	..	..	..	..	Test boring NR No. 18. For log see table 6.
R100	Hudson River, 1800 feet east of Seagate Rd.	C-4	do.	0	..	122	..	do.	..	..	..	..	..	Test boring NR No. 12. For log see table 6.
R101	2071 Clove Rd.	C-3	New York and Richmond Gas Co.	100	Drl	150	4	do.	T	35	35	F,I	..	Depth to water about 80 feet.
R102	66 Marine Way	B-3	Patrick Avino	10	Drl	40	1½	do.	S	..	..	D	..	Depth to water about 10 feet.
R103	Lynhurst and Tompkins Aves.	C-4	New York City Sanitation Garage	35	Drl	27	2½	do.	..	..	..	..	..	Test boring No. 4.

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